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A STUDY OF THE RELATIONSHIPS BETWEEN PERCEPTION AND READING.

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DESCRIPTORS- *VISUAL PERCEPTION, *READING PROCESSES, *SPATIAL RELATIONSHIP, WORD RECOGNITION, LOW ACHIEVERS, HIGH ACHIEVERS, READING ACHIEVEMENT, PERCEPTION TESTS, AUDITORY PERCEPTION,

A DEVELOPMENTAL STUDY OF PERCEPTION AND ITS RELATIONSHIPS TO READING AS MEASURED BY THE CALIFORNIA READING TEST, THE GATES- MCKILLOP DIAGNOSTIC READING TEST, A WORD REVERSAL TEST, AND A REVERSED WORDS IN CONTEXT TEST IS REPORTED. THE PERCEPTUAL TASK OF MATCH ADJUSTMENT WAS USED AS THE SPATIAL ORIENTATION MEASURE AND FOR BOTH SHAPE AND SIZE CONSTANCY. MATCH RECOGNITION WAS USED FOR SPEED OF PROCESSING INFORMATION. SUBJECTS WERE 50 SECOND, 56 FOURTH, AND 56 SIXTH GRADERS. THE RESULTS OF TESTS OF INTELLIGENCE, ACHIEVEMENT, SPATIAL RELATIONS, WORD REVERSALS, AND SIZE AND SHAPE CONSTANCY WERE ANALYZED. NONE OF THE INTERCORRELATIONS OF THE PERCEPTUAL TESTS WAS SIGNIFICANT. THE SPEED OF PROCESSING INFORMATION CORRELATED SIGNIFICANTLY WITH INTELLIGENCE, AND THE ACHIEVEMENT SCORES FOR ALL GROUPS ACCOUNTED FOR THE MOST VARIANCE. SPATIAL ORIENTATION AND REVERSALS WERE RELATED SIGNIFICANTLY TO ACHIEVEMENT IN BOTH FOURTH- AND SIXTH-GRADE GROUPS. WITH AN INCREASE AMOUNT OF INFORMATION, DIFFERENCES BETWEEN HIGH AND LOW ACHIEVERS BECAME SIGNIFICANT. SIZE AND SHAPE CONSTANCY PROVED AN IMPORTANT VARIABLE IN THE EARLY GRADES. THE RESULTS OF THE PROJECT POINT OUT THE IMPRACTICALITY OF THE SEARCH FOR GENERAL PERCEPTUAL ABILITY AND SUGGEST THAT NO SUCH ABILITY EXISTS. TEST INSTRUCTIONS AND A BIBLIOGRAPHY ARE INCLUDED. (MC)

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PA 24

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1967

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Finally, I wish to thank my wife, Kathryn, for her constructive ideas which helped to shape the design of the project.

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PROBLEM

This project is a developmental study of perception (size constancy, shape constancy, spatial orientation and speed of processing information about form) and its relationships to reading as measured by the California Reading Test, the Gates-McKillop Diagnostic Reading Test, a word reversal test and a reversed words in context test. Size constancy is defined as adjustment of a variable disc to match a standard presented at various distances; shape constancy as adjustment of a variable ellipse viewed obliquely until perceived as a circle; spatial orientation is measured in terms of adjustment of a rod to the apparant vertical under conditions of body tilt; and speed of processing information about form is defined as recognition of words and phrases flashed on a screen and followed by interfering stimuli (nonsense syllables).

The project was designed to provide information concerning three questions: Do the perceptual variables under study represent separate abilities? What relationships exist between the perceptual measures and reading achievement? Are there differences in perceptual skills among second-, fourth-, and sixth-grade children?

The above questions arose from a consideration of two problems which have beset previous studies in the area of perception and reading. The first of these is that such studies have not been carried out within a framework which adequately describes the scope of perception. Past studies characteristically have been concerned with a rather limited range of perceptual phenomena, namely form perception and speed of word recognition, while other perceptual variables, even those studied extensively in the laboratory, have never been used in investigations involving academic skills. The second difficulty associated with studies in perception and reading concerns the issue of subject selection. Developmental changes occur with respect to both perception and reading. Yet previous studies involving these two variables have often employed samples with limited age ranges.

THE STRUCTURE OF PERCEPTION

Consideration of the above problems suggested a series of developmental studies related to a general framework defining perception. The present project is the first in the series. The structure of perception model represents an effort to provide the defining framework. The structure is a classification system for determining possible definitions of perception and for applying them to educational problems. It hypothesizes separate abilities for each of the definitions which it produces. The model is built on the assumption that four variables define perception: the stimulus characteristic observed, the perceptual task of the observer, the content categories of the stimulus observed, and the sense modality through which the observation occurs.

Variables Defining Perception

Stimulus Characteristics. Stimulus characteristics, as the concept is used in this report, are the characteristics of external stimuli as perceived by an observer. Although stimulus characteristics are external to the perceiver, it is assumed that he plays a major role in defining them. The functioning of the perceptual apparatus involves the imposition of structure on incoming information. The order thus imposed in part defines stimulus characteristics. The stimulus characteristic, form, for example, is defined in part by perceptual functioning. Words like circle, square, triangle, etc., describe objects as they are perceived. The same objects could be described in terms of molecular arrangement or in any number of ways.

Stimulus characteristics are composed of dimensions, i.e. discriminable attributes capable of quantitative variation. When only one dimension describes a stimulus characteristic, that characteristic is a dimension. Size, for example, is a dimension. Position in space, on the other hand, is not a dimension but rather, is defined

by three dimensions.

Stimulus dimensions may be represented at constant or varying values which can impose limitations on perception. For example, a size limitation could be imposed on visual perception by presenting an object sufficiently small to be difficult to see.

Variations in value, in addition to limiting perception, provide a basis for establishing perceptual thresholds. For example, an investigator might limit pitch discrimination by presenting tones at varying intensities. He also might vary intensity for the purpose of establishing a threshold, e.g. the intensity at which an individual were capable of detecting a sound.

While experimental studies in perception are for the most part concerned with threshold measurement, assessment in education typically involves an effort to produce individual differences in perception by presenting stimulus values which can impose limitations on performance. No effort is made to establish thresholds. It is possible that valuable information is lost by the typical assessment procedure since threshold sensitivity is not necessarily correlated with performance under limitations imposed by stimulus values.

As an example, on a standardized test, even on a power test, the typical procedure is to base the subject's score on the number of correct answers. An alternate approach, analogous to measurement of threshold sensitivity, would be to determine scores on the basis of the point at which the subject began missing all items.

Limitations imposed by constant and varying dimension values play a major role in determining definitions of perception in that limitations on one dimension affect perception of that dimension and/or other dimensions. For example, a size limitation can affect size perception, form perception, position perception, etc. These interdimensional effects produce great complexity in the specification of definitions of perception by opening the way for generating definitions by combining stimulus characteristics. The systematic specification of such combinations will be discussed below.

Perceptual Tasks. A perceptual task is a set of requirements imposed on an observer. Task requirements serve two functions. They provide conditions which enable an observer to report what he has perceived, and to some extent they determine what the observer will perceive. The latter function has not been sufficiently emphasized in the study of perception. Too often the perceptual task is regarded primarily as a means of reporting perception. A specific task is seen as providing one of many possible ways to indicate experience. What is perceived is thought to be determined primarily by the stimulus characteristic being observed.

The lack of consideration of the perceptual task as a determinant of perception does not imply that its importance in defining perception is not known. Psychophysics, for example, specifies elaborate theoretical structures describing the role of various tasks in determining perception (Guilford, 1954). What is known about perceptual tasks, however, is often not considered in the construction of perceptual theory and in the development of techniques for assessing perception.

A perceptual task has three components: the number and arrangement of stimuli, the instructions to the observer, and the behavior required of the observer. Only the last of these serves to indicate what has been perceived, while all three of them play a role in determining what is perceived.

Variations in stimuli affect perception by altering what the perceiver can observe. The stimuli in a scanning task, for example, provide a different set of potential observations than the stimuli in a discrimination task.

Instructions determine what will be perceived in three ways: First, they play a well-known role in manipulating perceptual set or expectancy. Second, they affect attention. Third, they influence perception indirectly by guiding the behavior of the observer as he attends to the stimuli presented.

The control of set and attention effected by instructions, in part, determines the stimulus characteristic or combination of characteristics

which will be perceived. The presentation of a stimulus typically involves many characteristics. An observer may be asked to respond to all of these, to some combination of them, to his own selection of characteristics, or to just one characteristic.

The effect of instructions on behavior influences the reaction of the observer to the stimuli presented and his means of indicating what he has perceived. For example, the instructions in a visual discrimination task request the observer to engage in "comparison" behavior and tell him how to report the results of his comparisons.

The behavioral component of a perceptual task serves as the indicator of what has been perceived and determines perception by influencing the manner in which the perceiver makes selections from the stimuli available for observation. The "comparison behavior" in a discrimination task, for example, involves a different stimulus selection procedure and consequently a different set of experiences from the "search behavior" in a scanning task.

Contents. Content categories are culturally-determined classifications based on stimulus characteristics. The characteristic most extensively used in the definition of content categories is form. Some forms are classified as words, others as geometric shapes, etc. There is presumably no inherent basis for the establishment of content categories. A number or word presented visually, for example, is not basically different from a complex geometric design. However, because of cultural factors, people often respond differentially to certain categories of material. For instance, the existence of separate intellectual abilities for various content categories is well-documented (Guilford, 1960, Thurstone, 1944). Goins (1958), among others, has noted content-related differences in perceptual abilities.

Sense Modalities. Sense modalities refer to the types of senses through which information is processed. Each sense modality is responsible for processing a different kind of stimulus information and accordingly provides a different set of perceptual experiences from every other sense modality. Furthermore, there are restrictions on the

combinations of sense modalities with the other variables defining perception. That is, it is not always possible to select a stimulus characteristic, content, and response type, and investigate them under different sense modalities. For example, one cannot investigate loudness in the visual mode. Nevertheless, a certain amount of flexibility in combining sense modalities with other variables does exist, in that some stimulus characteristics, contents, and tasks are associated with more than one sense. Size, and texture, for example, are tactual and visual stimulus characteristics. Position in space is a characteristic associated with the visual, kinesthetic, olfactory, auditory, tactual, pain, and pressure senses.

The Classification System

The structure of perception model generates definitions of perception by specifying systematic combinations involving the four variables described above. Some of the definitions describe known measures of perception. Many more specify definitions which have never been the subject of empirical study.

Three types of combinations are used in the model: combinations involving sense modalities, stimulus characteristics, contents and response types; combinations of stimulus characteristics within a given sense modality; and combinations of stimulus characteristics from different sense modalities.

The Model. Type-one combinations generate definitions of perception directly, and thereby specify the structure of perception. For example, the combination of the stimulus characteristic, size in the visual mode with semantic content, and a discrimination response specifies a definition of perception. Type-two and type-three combinations generate groupings of stimulus characteristics which can be combined with the other variables in the model to produce definitions of perception.

The structure of perception built from type-one combinations is represented diagramatically in Figure 1 by a series of cubes, one for each sense modality. Each cube specifies that within a given sense modality, stimulus characteristic, contents, and perceptual tasks combine to produce definitions of perception. Dots represent structures for sense modalities not shown. (See Figure 1, Page 8).

Intra-modal Combinations. Earlier it was pointed out that stimulus dimension values can impose limitations on perception. Type-two combinations are produced by such limitations. Stimulus dimension limitations make it possible to combine each stimulus characteristic within a given sense modality with every other stimulus characteristic in that modality. Furthermore, any number of stimulus characteristics can be combined simultaneously.

An example of type-two combinations involving three visual stimulus characteristics is given in Figure 2, Page 9. The 12 combinations generated from only three characteristics illustrate the great complexity which type-two combinations produce in the definition of perception.

Inter-modal Combinations. The third type of combination specified by the structure of perception model involves stimuli from different sense modalities. It is possible to study a particular perceptual ability involving one sense modality under limitations imposed by stimuli from other sense modalities. Figure 3 indicates possible definitions of perception produced by combining a single visual stimulus characteristic, position in space, with stimuli from the auditory and kinesthetic modalities. (See Figure 3, Page 10).

Model Definitions As Constructs

The definitions of perception produced by the structure of perception model represent constructs which lie somewhere between theoretical constructs and operational definitions. The definitions generated by the model are desc iptive of operational definitions of perception. In contrast to the hypothetical constructs used in perceptual theory, they are not intended to infer abilities or characteristics of the

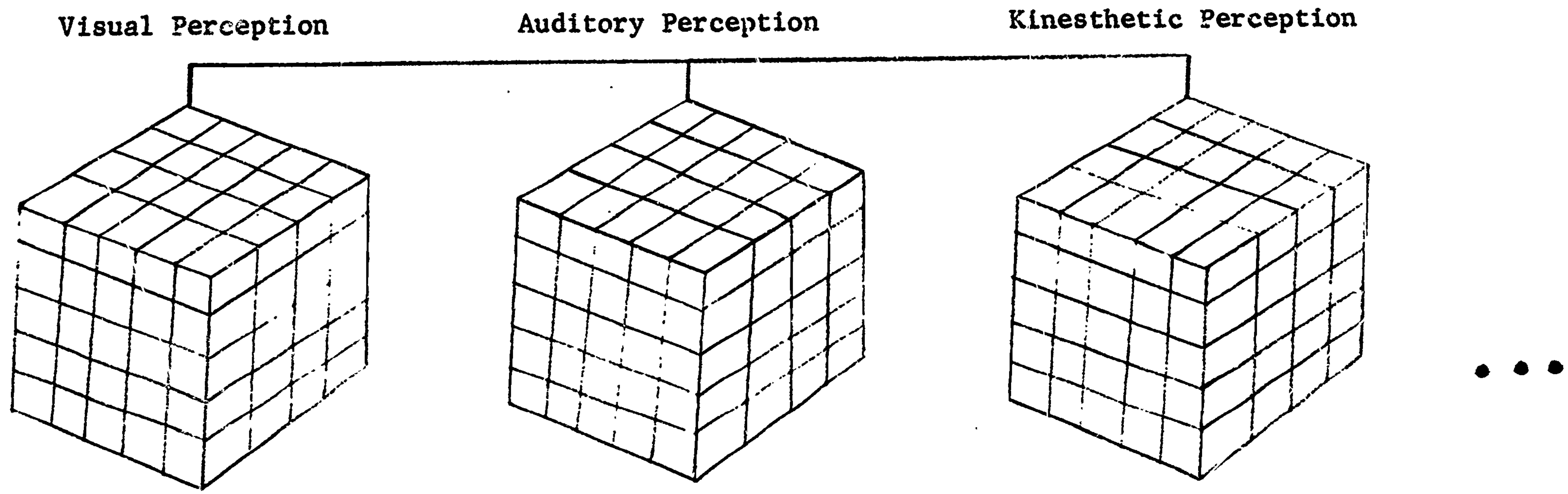

Figure 1

The Structure of Perception

Dots represent additional structures for other sense modalities. Cells represent combinations of stimulus characteristics, tasks, and contents. Lines connecting the cubes indicate definitions of perception based on inter-modal combinations.

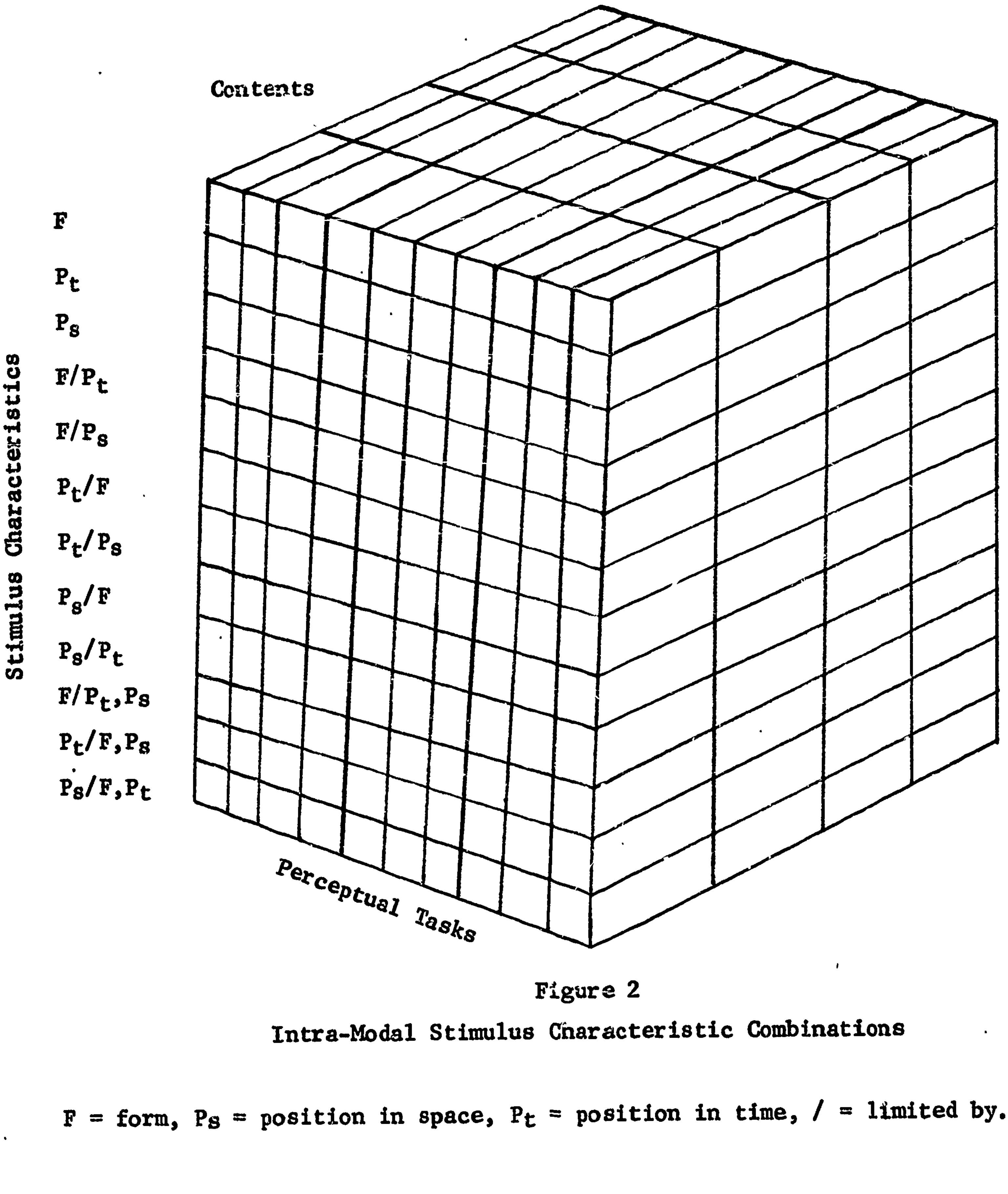

Figure 2

Intra-Modal Stimulus Characteristic Combinations

F = form, P_s = position in space, P_t = position in time, / = limited by.

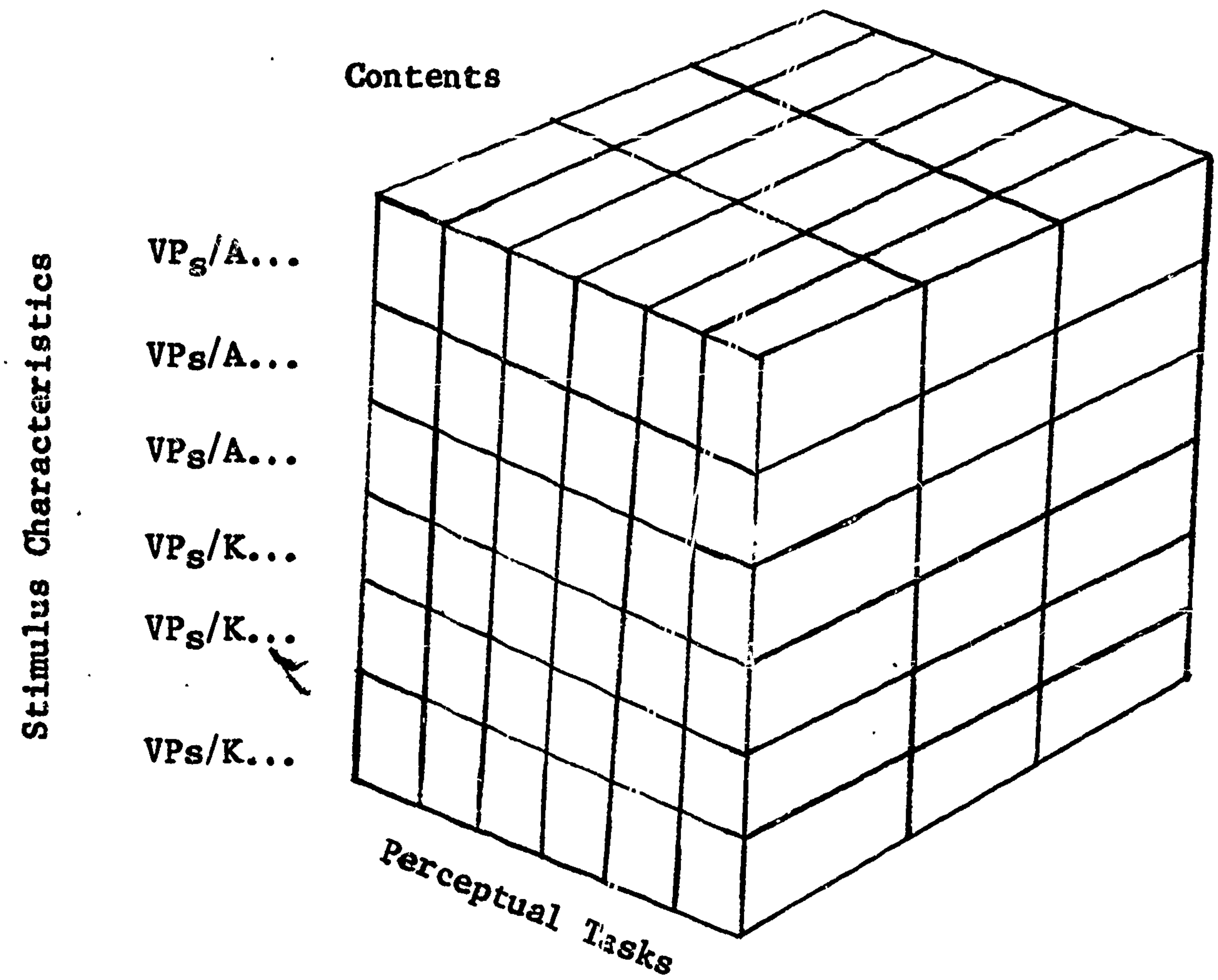

Figure 3

Inter-Modal Stimulus Characteristic Combinations

V = vision, P_s = position in space, A = audition, K = kinesthesis. Dots represent possible combinations involving P_s and each of the various stimulus characteristics within the auditory and kinesthetic modalities.

perceptual process. For example, visual form perception occurring under time limitations using a recognition task and figural content describes an operational definition of perception. The concept of speed of processing information, which could be associated with this description, infers something about the process of perception.

The structure of perception model provides a middle ground between theory and operational definition which clarifies the meaning of theoretical constructs and highlights potential limitations in the generality of such constructs. For instance, in the above example the meaning of the construct speed of processing information is clarified by relating it to the model definition: visual recognition of figural forms. In addition, the model definition suggests questions about the generality of the speed of processing construct. Specifically, it raises the issue of whether or not speed of processing information would be measured if various components of the model definition were altered.

Complexity Specification and Reduction

Typically a theoretical structure is an attempt to simplify the complexities of observed events. It is an effort to account for an abundance of facts in terms of a minimum number of relationships. The central function of the structure of perception model is to specify complexity rather than reduce it. This is not to say that reduction of complexity is not desirable. Indeed, a primary goal of the model is to facilitate attempts to reduce the complexity of categories defining perception. However, the model assumes that complexity reduction requires complexity specification.

The specification of complexity accomplishes two things: First, it provides a systematic detailing of features of perception which must be considered in efforts to reduce complexity. Second, it makes the refinement of theory compatible with complexity reduction.

Complexity cannot be reduced if it is not recognized. Psychological theory is replete with examples of unwarranted generalizations which have

arisen as a result of overlooking the complexity of events being studied. The possibility of overlooking salient factors in efforts to reduce complexity can be minimized by linking such efforts to attempts at complexity specification.

A long-overlooked problem in the utilization of scientific theory is that of insuring the compatibility of theory refinement and complexity reduction. The refinement of scientific theory and the reduction of complexity with respect to the explanation of observed events are typically mutually exclusive outcomes. Results supporting a theory are highly desirable because they eventuate in a reduction in complexity. Yet the occurrence of supportive results does not lead to a refinement of theory. The scientist who receives support for a theory from data does not need to alter the theory.

Specification of complexity makes it possible to make theory refinement and complexity reduction compatible. The structure of perception model illustrates this fact. The model hypothesizes the existence of separate abilities for all of the definitions represented in the structure. The discovery of relationships among perceptual abilities, while eventuating in a reduction in complexity, does not support the model. The structure must be altered whenever relationships are found. Thus reduction in complexity is accompanied by refinement in theory.

Methods for Reducing Complexity

Efforts to apply science to educational practice and to other fields often do not include recognition of the fact that the hypothesis-testing approach provides only one of many means for reducing complexity. In some instances hypothesis testing does not offer an appropriate or practical approach to complexity reduction. In other instances the hypothesis-testing method can and should be combined with other approaches. The material which follows is a discussion of possible ways for reducing complexity associated with the structure of perception model.

Procedures for reducing complexity can be grouped into two headings: category selection and category combination.

Reduction by Category Selection. Selection reduces complexity by defining substructures which eliminate certain definitions of perception from consideration. Reduction by selection is determined by two factors: the relevance of definitions with respect to whatever goals are to be achieved by selection, and the procedures or strategies used in the selection process.

Definitions of perception within the model can be selected on the basis of their relevance to the achievement of some goal. For example, if one's goal were to study relationships between perception and reading, a set of priorities with respect to the relevance of various aspects of perception in reading could be established prior to conducting any investigations. Visual perception is clearly more important in reading than olfaction, taste, pressure sensitivity, and so on. Selection based on goal relevance would suggest that visual perception be studied and the other senses listed be eliminated from consideration. There is some risk in eliminating topics on the basis of relevance, but the risk is far outweighed by the savings in time and expense which result from this method.

The first step involved in the reduction of complexity based on relevance is to specify goals and the tasks involved in achieving them. System theory provides a useful means for accomplishing this. The achievement of goals typically involves the interrelated functioning of several components. A plan to insure goal achievement must include a description of the overall goal, numerous subgoals, and the tasks and operations attendant to reaching them. With the advent of system theory, a powerful tool for describing the complex interactions involved in goal achievement became available. The consideration of individual tasks and subgoals not as isolated entities, but as components of a system functioning to accomplish an overall goal, makes it possible to specify and to evaluate tasks and subgoals by relating them to the overall goal.

A commitment to the system theory approach is useful not only in reducing complexity, but also in suggesting a redefinition of the concept of ability and its application to the structure of perception model.

Abilities are typically defined without reference to the tasks in which they are used. For example, it is known that there is a relationship between intelligence and reading ability. But how does intelligence function in the reading process? What is needed to answer questions like this is a description of the task of reading (what in system theory is called a job description) and an analysis of the psychological processes necessary for carrying out the task, (in system-theory language, a task analysis).

Task analyses based on job descriptions could provide a framework for defining abilities on the basis of their relationship to task performance. For example, the reading task requires the reader sequentially to take in units of information visually. One unit of information must be processed to a sufficient extent to allow additional information to enter the system before the next unit can be received. The faster the reader can accomplish information processing, the faster he should be able to read. Speed of processing information about semantic forms, then, could be defined as an ability.

The above approach defines abilities by specifying psychological processes as they occur during task performance. Concepts like intelligence, creativity, perceptual ability, and so on do not describe the way human beings function in carrying out tasks.

The specification of the operation of abilities in task performance could prove useful in relating consideration of abilities to training and evaluation efforts in education. The area of reading offers an illustration of this possibility. Defining abilities in terms of their operation during reading could lead to the design of programs which not only would provide instruction and evaluation in reading, but also would give instruction and evaluation in the abilities necessary for reading to occur.

Selection is typically a sequential process involving many choices. The number of choices necessary to achieve a goal can vary with the strategy used to make choices. Consequently, complexity reduction is affected by strategy.

A variety of selection strategies can be used to reduce complexity associated with the structure of perception model. Model simplification could be achieved by using a random sample of definitions of perception to represent the structure of perception. For example, a substructure based on random selection might be applied to the study of perception and reading as follows: Information concerning the contribution of perception to the reading process might be attained by randomly selecting definitions of perception from the structure of perception model and assessing the relationships between perception measured in terms of these definitions and reading achievement.

Bruner et al. (1956) have described three selection strategies which could be used to reduce complexity: conservative focusing, focus gambling, and negative focusing. All of these strategies apply in situations in which the goal of selection is to determine what definitions of perception properly belong within a given category.

Conservative focusing as applied to the structure of perception model is an attempt to reduce complexity by minimizing the number of choices necessary to group definitions of perception into categories. In applying this strategy to the model, category membership is determined by selecting a definition of perception which clearly belongs within a category and eliminating irrelevant components from consideration by testing successive hypotheses which always involve all but one of the components of the definition originally selected. For example, consider the application of conservative focusing to the problem of determining whether or not the category designated as ability in speed of processing information generalizes across stimulus characteristics, contents, and tasks. An investigator interested in this problem might begin by selecting visual form perception occurring under a time limitation using a recognition task and semantic content as an example of the category. He then might introduce alterations in stimulus characteristics, content, etc., to test the relevance of these components. Under this procedure some components would very likely be eliminated from consideration almost immediately. For example, the first alteration in the perceptual

task component might yield significant changes in performance. If this were to occur, it would not be necessary to vary that component further since it would be evident that speed of processing information ability did not generalize across tasks. This example illustrates the advantage to the conservative focusing strategy: namely that it reduces the number of choices necessary to determine category membership.

Application of focus gambling to the structure of perception model differs from the application of conservative focusing in only one respect: Variations occur in more than one component of a perceptual definition at a time. The focus gambling strategy has the potential to reduce the number of choices necessary to determine category memberships to an even greater extent than is the case with conservative focusing. However, there is a risk involved in applying the strategy. If in changing two or more components, it is determined that the perceptual definition under study is no longer measuring the same thing as assessed by the originally-selected definition, there is no way of knowing which of the altered components is responsible for the alteration in performance. Thus additional selections must be made.

Negative focusing may be applied to the model to determine category membership in disjunctive categories. For example, suppose disabilities in reading caused by lack of ability in speed of processing information were a disjunctive category involving sets of definitions from the visual and auditory senses. If this were the case, poor performance in reading could be related to either a lack of auditory speed or visual speed. The proper approach to prove the relevance of these two senses would be first to find children who did not exhibit reading disability. Then groups of children would be assessed, each of which differed from the original group on only one potentially relevant variable. If speed of processing disabilities in reading were actually a disjunctive concept, each time a relevant component were introduced reading disability would appear. The appearance of the disability would attest to the relevance of the newly introduced component.

Reduction by Category Combination. Complexity reduc-

tion resulting from combining categories can occur in two ways: The first results from hypothesized and demonstrated relationships which indicate that categories should be combined, and the second results from defining a hypothetical construct which includes several categories.

The classical scientific approach, involving hypothesis testing based on theory, provides a way of reducing complexity, the value of which has been demonstrated on countless occasions. There is no reason that this approach could not be applied to the structure of perception model. Indeed, if it were successfully applied, a most beneficial reduction in complexity might be achieved. If, for example, it were to be hypothesized and demonstrated that certain perceptual abilities generalized across perceptual tasks, a useful simplification of the structure of perception model would be effected.

A second way to reduce complexity by combining categories is to create a hypothetical construct which includes more than one category. The best known example of a hypothetical construct combining categories is the construct of intelligence. The items and/or subtests on an intelligence test typically represent a wide variety of tasks which in many cases are not highly related. Presumably because of their predictive value, the items are grouped into a single construct, intelligence. Since most criterion behavior, especially in education, is highly complex, the chances of accurately predicting criterion performance are enhanced by grouping items in this way.

The hypothetical construct approach could be used to reduce complexity in the structure of perception model. A large number of definitions of perception, each bearing some degree of relationship to various criterion behaviors such as achievement test performance, could be grouped into a single test measuring "perceptual ability". The central advantage of this kind of procedure is that it enhances prediction. The central disadvantage to the method is that it does not relate the definition of perception to task performance.

SELECTION OF PERCEPTUAL MEASURES

The Structure of Visual Perception

The perceptual measures used in the present project may be defined in terms of the model given in Figure 4, Page 19. Each cell in the model represents a definition of visual perception formed by the combination of a stimulus characteristic, content, and perceptual task. Intra- and inter-modal interactions are given only when they represent characteristics selected for study in the present project.

Stimulus Characteristics. Below is a description of the stimulus characteristics for visual perception and some discussion of the dimensions which define them.

Form refers to the structure or shape of objects. Efforts to define form in terms of quantifiable dimensions have been extensive and the problems associated with them formidable. Many dimensions have been isolated and studied. However, the task of identifying dimensions is by no means yet complete. A detailed review of the literature dealing with the dimensions of form has been presented by Michels and Zusne (1965). These writers describe three kinds of form dimensions: transitive, transpositional, and intrasitive. Transitive dimensions are defined by quantitative variations in structure and information content. An example of quantification along a transitave dimension is the number of inflections in the contour of a shape, i.e. the number of sides it has. Alteration of the number of sides changes the shape of the object and the amount of information associated with it.

Transpositional dimensions involve changes which do not affect structure or information content. Size and spatial position are two examples of transpositional dimensions. In the present model, the dimensions which Michel and Zusne group under the heading of transpositional dimensions are considered to be stimulus characteristics separate from form.

Intransitive dimensions are defined by quantitative variations in

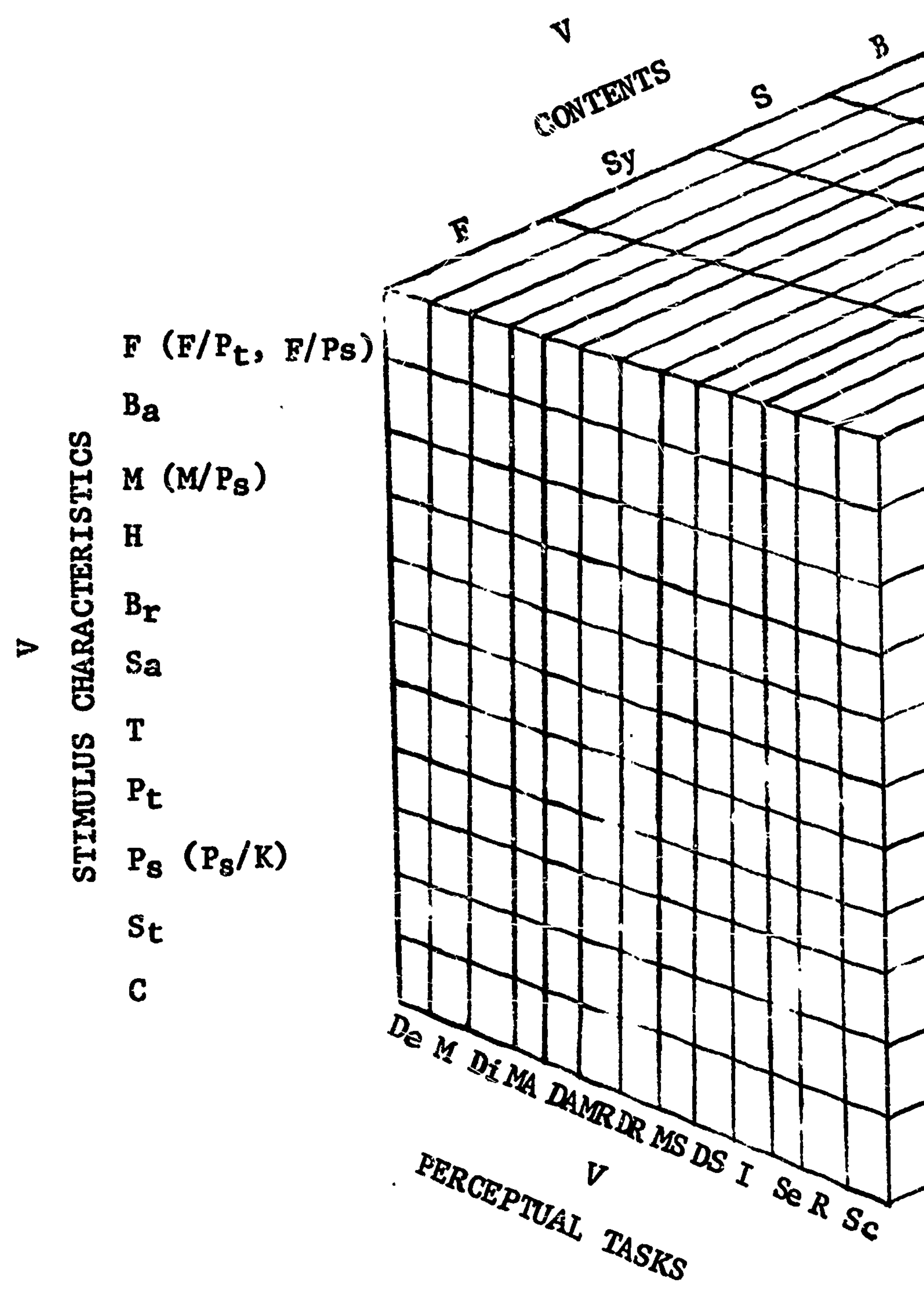

Figure 4

The Structure of Visual Perception

Sense Modality: V - Visual; Contents: F - Figural, Sy - Symbolic, S - Semantic, B - Behavioral; Stimulus Characteristics: F - Form, F/P_t - Form limited by time, F/P_s - Form limited by spatial position, B_a - Background, M - Magnitude, M/P_s - Magnitude limited by spatial position, H - Hue, B_r - Brightness, S_a - Saturation, T - Texture, P_t - Position in Time, P_s - Position in Space, P_s/K - Spatial position limited by kinesthetic input, S_t - Stability, C - Change; Perceptual Tasks: D_e - Detection, M - Matching, D_i - Discrimination, MA - Match Adjustment, DA - Discrimination Adjustment, MR - Match Recognition, DR - Discrimination Recognition, MS - Match Scanning, DS - Discrimination Scanning, I - Identification, S_e - Selection, R - Reproduction, S_c - Scaling.

structure, but not information content. Changing the length of the base of a triangle is an example of variation along an intransitive dimension. The object changes shape, but it remains a triangle. Its structure is altered, but its information content remains the same.

Background is the field in which a figure or form exists. Background is defined in part by the boundaries of the figure it contains and in part by its own structural makeup. Presumably background is defined by the same dimensions which define form. However, this may not be the case. Current literature is lacking in studies dealing with the dimensional character of background.

Magnitude, hue, brightness, saturation, and position in time require no comment. They are all well known unidimensional characteristics.

Texture refers to the discriminable characteristics of the surface of an object. Texture, like form, involves structure or pattern and is multidimensional. Systematic investigations into the dimensional nature of texture are lacking at the present time.

Position in space refers to the location of an object in three-dimensional space.

Stability is the extent to which an object remains the same over time with respect to one or more of the dimensions which define it. Conversely, change refers to alterations in one or more dimensions over time. Stability and change are characteristics of characteristics. An object has a certain stability of form, stability of size, stability of spatial position and so on. Similarly an object can change with respect to form, size, position, etc.

The above description of stimulus characteristics indicates wide variation in the ease and clarity with which dimensions defining stimulus characteristics can be specified and in the complexity of stimulus characteristics. Size on the one hand is easy to define and quantify. Form, on the other hand, is highly complex and difficult to dimensionalize.

Four stimulus characteristics were selected for study in the present project: F/P_t (form under time limitations), F/P_s (form under

limitations of position in space), M/P_s (size under limitations of position in space), and P_s/K (position in space under variations in kinesthetic stimulation).

Perceptual Tasks. The following list provides descriptions and gives examples of the perceptual tasks in visual perception. All of the perceptual tasks listed involve making judgments concerning a standard. Standards can be external or internal. For example, adjustment of a rod to the apparent vertical involves an internal standard: the perceiver's internal representation of verticality. Recognition of words flashed on a screen involves an external standard: the flashed words. With the exception of scaling tasks, which typically do not make use of external standards, the list given below describes tasks with external standards. Corresponding descriptions could be given for tasks with internal standards.

Detection indicates perception of something without specifying what has been perceived; e.g. indicating whether or not a word has flashed on a screen within a given time period.

Matching involves judging the similarity between stimuli; for example, judging whether or not one design is the same in shape as another.

Discrimination is judging differences between stimuli.

Match adjustment is adjusting a variable stimulus to match a standard; for example, adjusting a circle which can vary in size to match the size of a standard circle.

Discrimination adjustment is adjusting a variable stimulus until it is different from a standard.

Match recognition is selecting from a series of alternatives the stimulus which matches a standard; e.g. selecting a word from a prepared list to match a word flashed on a screen.

Discrimination recognition is selecting from a series of alternatives the one which is different from the others; e.g. selecting the shape which is different from other shapes in a series.

Match scanning is finding other examples of a standard stimulus in a complex stimulus situation; e.g. finding all of the circles in a

large group of geometric shapes.

Discrimination scanning is judging whether complex stimuli are the same or different in all respects; e.g. discriminating between two words which are the same except for their ending letters.

Identification is denoting what is seen; e.g. naming words flashed on a screen.

Selection is indicating what is perceived in a complex and sometimes ambiguous stimulus situation; e.g. telling what is seen in an ink blot. The blot is an ambiguous stimulus capable of giving rise to a large variety of responses.

Reproduction is duplicating a standard; for example, copying a square.

Scaling is arranging stimuli with respect to a given characteristic; e.g. arranging sticks in order from the largest one to the smallest one. There are several scaling procedures. For a detailed discussion of these, see Dember (1960).

Two perceptual tasks were used for the present research: match adjustment and match recognition. Match adjustment with an internal standard was used for the spatial orientation measure. Match adjustment with an external standard was used for both the shape and size constancy tests, and match recognition with an external standard was used for the speed of processing information measure.

Contents. The content categories used in the model are those specified by Guilford (1960) in connection with his description of the intellect. Figural content is concrete material; for example, geometric shapes. Symbolic content is composed of signs; e.g. numbers, letters, etc. Semantic content refers to meaningful verbal units; e.g. phrases and sentences. Behavioral content refers to social stimuli; e.g. facial expressions, gestures, etc. Semantic content was used for the speed of processing information test. Figural content was used for the other perceptual measures.

Rationale for Selecting Perceptual Measures

To determine the measures of perception used in the project, the

complexity represented in the visual perception model was reduced by goal-related selection. The goal was to broaden the scope of perceptual variables studied in relation to reading. Measures were selected which had been studied extensively in the laboratory, but not in an educational setting, and which, on the basis of task analyses, could be assumed to be related to reading achievement.

(VF/P_tRS), speed of processing information, was selected for study because the reading process involves stringent time limitations. A reader encounters a series of visual stimuli, each of which is time limited by the perception of the neighboring units in the series.

Shape and size constancy, (VF/P_sAmF and VM/P_sAmF), were chosen because the act of reading, like shape and size constancy, requires accuracy of judgments of shape and magnitude of stimuli under variations of the position of these stimuli in space.

($P_s/KAmF$), spatial orientation, under limitations imposed by kinesthetic input, was selected because accurate reading requires the ability to judge the spatial relationships between words and letters as well as the forms of words and letters and because such ability may be based on the integration of kinesthetic and visual information. Judgment of the position of an object in space involves the perceiver's perception of both the object's position and his own position with respect to it. The perceiver's judgment of his own position is based in part on kinesthetic information. His judgment of the object is based on the integration of this kinesthetic information with the visual information provided by the object.

RELATED LITERATURE

Perceptual Speed

Perceptual Speed and Reading. Recognition of the importance of perceptual speed in skill in reading grew out of attempts to identify a general perceptual ability and to establish its relationship to reading achievement. Goins (1958) reports an early study by Gates which served as a foundation for later work. In Gates' study, which involved 3rd- through 8th-grade children, tests of visual perception (discrimination measures involving words, nonsense syllables, and geometric shapes) were found to be poorly correlated with each other and with achievement. However, when Gates used tests which involved distinguishing between the correct form of a word and incorrect alternatives, he obtained a high relationship with reading. Gates concluded from results of the above study and later studies that a general perceptual ability did not exist and that content was more important in reading than perceptual process.

Goins cites studies by Sister Mary of the Visitation and Sister Mary Phelan using 4th- and 6th-grade children which support Gates' contention that tests involving words are more closely related to reading skill than tests in which word perception is not included. However, these studies did not support Gates' conclusion that a general perceptual ability does not exist. Sister Mary of the Visitation found evidence for a group factor describing general perceptual skill. Sister Mary Phelan also found relationships across tests. However, she concluded that these relationships were more a reflection of item content than perceptual process.

Goins cites an investigation by Langsam as one of the earliest studies revealing a perceptual speed factor. The Langsam study, like those of Gates, Sister Mary of the Visitation, and Sister Mary Phelan was an effort to identify a general perceptual ability and assess its relationship to reading. Langsam factor-analyzed a series of tests including reading measures and some perceptual tests developed by Thurstone. She isolated a perceptual speed factor which included four verbal tests and a non-verbal measure, Thurstone's identical forms test.

At about the same time as the Langsam study, Thurstone, using college students, demonstrated a relationship between perceptual speed and reading speed. In Thurstone's study, fast readers demonstrated superior size constancy, were better at identifying dotted outlines of letters and digits, and were able to fuse flickering images at higher frequencies than slow readers.

Goins (1958) confirmed the relationship between perceptual speed and reading at the 1st-grade level. The effects of content demonstrated in early studies of perception and reading suggested to Goins the importance of investigating perception and reading in young children. Goins felt that the heavy emphasis placed on verbal skills in school might be responsible for obscuring relationships between perceptual abilities of a non-verbal nature and reading skill. Accordingly, she composed a battery of 14 non-verbal tests and administered these along with reading achievement measures to 1st-grade children.

In order to determine whether or not her tests measured a general perceptual ability, Goins factor-analyzed the measures in her battery. Two factors were revealed: the ability to hold a perceptual gestalt in mind during rapid perception, and perceptual speed.

Examples of tests loading significantly on the perceptual gestalt factor are the controlled association test and the cancellation test. In the controlled association test the child is required to identify common elements in a series of pictures; for example, all of the wheels in a series. On the cancellation test, the child is required to cross out specified digits or letters when encountered in a row of figures. Pictures of animals and other familiar things are substituted for letters or digits with young children.

Examples of tests loading heavily on the speed factor are the pattern-completion and pattern-copying tests, both of which are timed. The pattern-completion test requires the child to draw in the missing line necessary to complete a pattern. The pattern-copying test requires the child to draw in several lines necessary to complete complex patterns. Each completed pattern is to match a model which is presented with it.

Goins found a rather substantial relationship (.49) between total test performance on her perceptual battery and reading achievement. The basis for this relationship was determined to rest almost entirely with correlations between measures of perceptual speed and reading ability.

Perceptual Speed Training, Tachistoscopic Studies. Since perceptual speed has been found to be related to reading instruction, it might be expected that training designed to improve perceptual speed would enhance reading performance. The results of studies seeking to demonstrate such enhancement, however, have been inconclusive. Jones and Van Why (1953), for example, used groups of 4th and 5th graders matched on the Iowa Silent Reading Test in a study of the influence of tachistoscopic training on reading rate and comprehension. Each grade was divided into an experimental group (receiving 3 months of daily tachistoscopic training) and a control group (receiving no training). Pre- and posttests were given to all groups. Although there was a significant gain in reading rate for the experimental group in Grade 4, there was no such gain for the 5th grade.

Effects of tachistoscopic training with 1st-grade children have been reported by Goins (1958). Goins concluded that "no positive effect was produced by tachistoscopic training on the reading skills of the group..." She stated, however, that her findings did not rule out possible value of tachistoscopic training for selected older pupils with specific perceptual difficulties.

Tachistoscopic training does have an effect on perception. Schaffer and Gould (1964) investigated the influence of tachistoscopic training on eye movement patterns during a scanning task. They found that the tachistoscopically-trained group scanned more quickly and with fewer fixations per line, but made significantly more errors than the group with no such practice.

Perceptual Speed Training, Controlled Reader Studies. When controlled readers are used, the results of training procedures are more encouraging than is the case when tachistoscopes are employed. Thompson (1956) compared the effects on reading performance of a 21-hour book-centered and a 21-hour machine-centered course. Four hundred thirty-eight

officers at an air command staff school were divided into three groups: two experimental and one control. The experimental groups were trained with the reading rate controller while the control group used a book describing useful reading habits. The results showed that all groups gained significantly in speed; however, the book-oriented course brought about a higher mean speed than the machine-oriented course.

In a study using 150 college freshmen, Weeden (1954) found gains in reading rate, comprehension and general reading ability for a group trained with the reading-rate controller and a group trained with a book on reading techniques. No gains were found for a group receiving no instruction. The test-retest findings showed that the group using the reading-rate controller made greater improvement in rate than the book-trained group, but that both groups were equal in all other skills.

Smith (1953), working with college students, combined periods of tachistoscopic training and work with a controlled reader. Weekly tests of rate and comprehension on fictional material were presented along with other standardized tests of intelligence and achievement. The results showed that only a "small proportion of the speed increase demonstrated on the controlled-reader tests transferred to reading independent of the controlled-reader apparatus, and there was some loss in the area of comprehension." Pre- and post-opthalmograph records showed a substantial drop in the number of fixations per hundred words, and the number of regressions was nearly cut in half.

Speed of Processing Information. Gilbert (1959) has distinguished two kinds of perceptual speed: speed of recognition and speed of processing information. The techniques devised by Gilbert to measure speed of processing information were used in the present project. In the speed of recognition type task a stimulus, typically a word or phrase, is flashed on a screen. The subject's task is to identify the stimulus. The crucial characteristic of this type of measure is that the subject has unlimited time to recall what he sees on the screen. The tachistoscopic training studies described above are examples of speed of recognition tasks.

In the speed of processing information task, the subject does not have

unlimited time to recall the stimulus which he is attempting to identify. The ability to process the information presented by the stimulus is limited by the onset of other stimuli.

To assess the importance of the distinction between speed of recognition and speed of processing in reading, Gilbert asked college students to identify words flashed for short periods of time on a screen. In one condition the students were allowed as much time as necessary to make their identification before any new stimuli appeared. In a second condition, the onset of an "interfering" stimulus limited identification time. Gilbert found no significant correspondence between speed of recognition and reading skill. However, he did observe a significant relationship between speed of processing information and rate of reading comprehension.

The effectiveness of controlled readers in improving reading skill may be explained in part by Gilbert's distinction between speed of processing information and speed of recognition. Performance using a controlled reader might be considered to require essentially the same behavior as speed of processing information in that the controlled reader does not allow the individual unlimited time to process the content he is reading.

Factors Affecting Information Processing. Oostlander and de Swart (1966) assessed the effects of redundancy (i.e. multiple presentation of the same stimulus) on visual discrimination using figural forms with tasks of varying difficulties. They reported a facilitation of task performance with increasing redundancy when the task was easy (selecting from several classes of stimuli the category with the fewest number of examplars); however, with a difficult task (summing the number of examplars in each stimulus class), redundancy did not facilitate performance.

A number of studies have attempted to determine whether large units of information are processed all at once or are broken into small units which are processed serially. A study by Weisstein (1966) with adults indicated that perceptual processing of an array of letters occurs in part serially and in part in large units. Subjects did not process one letter at a time, nor did they process all letters at once.

Newman (1966), in studying word perception in adults, found that when

fewer than three letters were presented at a time reading performance was impaired. Information processing in reading does not require large chunks of information, but nevertheless does not occur in letter units.

Green and Courtis (1966), studying visual identification of figural forms in adults, found evidence to suggest that the ability to process large amounts of information is related to perceptual strategies determined partially by past experience. They identify two stages in processing stimulus information: identification of the class to which the observed stimulus belongs and identification of the unique characteristics of the stimulus. Class identification is determined by what the perceiver expects to see. His expectancies determine the points of reference in the figure which he will use to identify it.

The influence of interfering stimuli on information processing has been investigated widely. The term "masking" is often used to describe interfering effects. Masking denotes the process by which the threshold of perception for one stimulus is raised by the presence of another stimulus. In backward masking, the interfering stimulus follows the test stimulus. Raab (1963) has reviewed the literature dealing with backward masking. He reports that backward masking has been demonstrated for visual, auditory, and cutaneous stimuli.

Studies of visual masking are of three types: In the first type, labelled the Broca-Sulzer type, the masking stimulus and the test stimulus are presnted in the same target area. Masking of this type actually does not involve an interfering stimulus separate from the test stimulus. Masking is produced by lengthening the duration of the test stimulus. In the second type of study, the metacontrast study, the masking stimulus occupies adjacent areas to the test stimulus. In the third type of study, the Crawford type, the test stimulus is included in the area used to present the masking stimulus.

In 1902 Broca and Sulzer demonstrated that an increase in perceived brightness of a test stimulus occurred with exposure durations up to about 50 msec. (Raab, 1963). From 50 to 200 msec., perceived brightness decreased. These findings, which have been verified many times, constitute what has

since been called the Broca-Sulzer effect.

Metacontrast studies indicate that masking can occur when there is a time separation between the test and masking stimulus and when the masking stimulus surrounds, but does not include, the area occupied by the test stimulus. Raab cites a study by Alpern suggesting that the apparent brightness of a flash of light is reduced when followed by a second flash in an adjacent area of the visual field. Alpern found that metacontrast masking is a U-shaped function of the amount of time between the test stimulus and masking stimulus. As time increases up to 100 msec., masking effects increase. After 100 msec. masking effects decrease with time. Metacontrast masking increases with increases in luminance or duration of the masking stimulus, or with decreases in duration of the test flash. Masking decreases as the masking stimuli are spatially removed from the area of presentation of the test stimulus.

Studies of the Crawford type have indicated that backward masking occurs when the entire area of the test stimulus is covered by the masking stimulus which follows it. Furthermore, masking occurs with as much as 100 msec. between test and masking stimulus.

Eriksen has directed a number of studies to determine the basis for backward masking. He has shown that there are at least two causes for the masking effect: the first has to do with the tendency of the visual system to sum luminances over time. Eriksen and Lappin (1964) pointed out that "presentation of an illuminated field at short intervals prior to or following a field containing a form or display will have the effect of adding equal luminance to both the figure and ground of the display. This results in a reduced figure-ground contrast, with resulting impaired recognition of the display."

The second basis for masking offered by Eriksen suggests that the masking stimulus adds complexity to the test stimulus. The complexity explanation is offered in opposition to the "erasure" model, which suggests that the masking stimulus erases the test stimulus percept. In support of the complexity view, Eriksen and Collins (1965) found that maximum masking occurred when the masking stimulus and test stimulus were

presented simultaneously. Furthermore, when the masking stimulus was presented before the test stimulus, masking occurred. The demonstration of forward masking and masking with simultaneous presentation of the masking and test stimulus point out the inadequacy of the "erasure" hypothesis. It is impossible to erase a percept before it occurs. In neither forward nor simultaneous masking does the percept occur before the masking stimulus.

In a further investigation related to the complexity hypothesis Eriksen (1966), using college students, determined that when two symbolic stimuli (letters) were flashed consecutively on different parts of the fovea, perceptual processing of one stimulus was independent of the other stimulus even when the delay between stimuli was only 1 msec. Masking did not occur. There are two especially significant features of this study: First, Eriksen controlled the effects of luminance. Second, the masking stimulus did not surround the test stimulus and thereby add complexity to it.

Ambiguities in the Definition of Perceptual Speed. The tests used to measure perceptual speed in the studies described by Goins were not selected in any systematic way. Therefore, it is difficult to determine with any precision what features within these tests constitute the necessary defining characteristics of the speed factor. Correspondingly, it is not certain that tachistoscopic and controlled reader training studies always have included the variables necessary to define perceptual speed.

Gilbert's speed of processing information could serve as a starting point for resolving ambiguities in the definition of perceptual speed and in the findings of tachistoscopic and controlled reader studies.

Speed of processing information could be defined in terms of the structure of perception model, and a focusing strategy used to create systematic variations in the definition. Whenever an alteration produced a change in performance, it would be known that the altered variable played a crucial role in defining speed of processing information. When

the defining features of speed of processing information were known, they would provide a basis for classifying other measures of perceptual speed.

Spatial Orientation

Types of Spatial Judgments. The position of an object in space can be judged in terms of its relation to a perceiver. Three types of judgment may be involved: First, the object may be considered as a point in space, in which case interest might be directed toward describing judgments of the distance of the object from the observer. Second, the object may be considered as a line in a two-dimensional space, and the perceiver required to judge the position of the object in that space. Finally, the object may be described by a three-dimensional space, and the perceiver required to identify the position of the object in that space. It is the second of these types of judgments which is of concern in this project.

Developmental Studies of Spatial Orientation. There are marked differences between young children and older children in the ability to make accurate judgments of the position of objects in two-dimensional space. These differences exist for figural, symbolic, and semantic content. With respect to figural content, one of the most persistent findings is that young children do not readily perceive the position of geometric shapes with respect to such dimensions as horizontal and vertical. Ling (1941), for instance, found that the discrimination of objects by infants was independent of whether the stimulus objects were upside-down or right-side-up. Frank (1935) noted that 6- and 7-year-old children had difficulty in distinguishing playing cards from their mirror images. Newson, in a study quoted by Vernon (1957, p.17), indicated that 5-year-old children were often unable to distinguish a shape from its mirror image even when the distinction was pointed out.

Davidson (1934), using the symbolic mode, demonstrated that children under 6 years of age were likely to confuse reversed and inverted letters, such as "p" and "d" and "d" and "b". Reversal errors were observed to continue up to a mental age of 7½ while inversion errors ceased at

approximately a mental age of 6. Hill (1936) observed that reversals were more prevalent when letters were presented in a word than when they were presented alone.

Errors with regard to the position of letters with respect to other letters in a word are very common. Davidson (1934) noted that a large percentage of the errors made by 5- and 6-year-old children in word recognition involved word reversals. Ilg and Ames (1950) found that reversals and letter transpositions within words were present in children until approximately the age of eight.

Psychological Processes Determining Positional Judgments. Werner and Wapner and Witkin offer theoretical descriptions of the psychological processes which determine accurate positional judgments. Werner and Wapner hypothesize that accuracy in spatial orientation is attained through the integration of information from more than one source. The results of their studies dealing with influence of combinations of visual and kinesthetic and visual and auditory stimuli upon the perception of the position of an object in space have consistantly provided support for this assumption (Werner and Wapner, 1952).

Witkin (1962) has provided a theoretical interpretation of individual differences in performance on tasks involving positional judgments. In developing his theoretical framework, he has studied the relationships between several perceptual tasks and the ability to make positional judgments under limitations imposed by kinesthetic input. Witkin argues that performance under conditions such as those used by Werner and Wapner provides a measure of field dependence: the degree to which an individual's judgments of a stimulus are affected by the field in which the stimulus is presented.

Witkin uses three tests to measure field dependence: the rod and frame test, the body adjustment test and the embedded figures test. The subject's task in the rod and frame test is to adjust a rod to the apparent vertical under conditions of body tilt. The rod is presented inside a frame which is also tilted during the test. The rod and frame test was used in the present project to measure judgments of

position in space under variations in kinesthetic input.

In the body adjustment test, the subject is placed in a tilted chair inside a room which is also tilted. His task is to adjust the chair to the upright position.

In the embedded figures test, the subject is asked to find a simple figure within a larger complex figure. The simple figure is hidden by being incorporated into the pattern of the complex figure.

Most of the correlations which Witkin reports among the three measures of field dependence fall between .30 and .60. Witkin concludes on the basis of these relationships that the three tests measure virtually the same thing.

Witkin and others have assessed the relationships among field dependence measures and performance on other perceptual tests. Witkin reports several investigations which indicate strong relationships between flexibility of closure and field dependence measures. In these studies, flexibility of closure is measured by three tests, the Thurstone-Gottschaldt figures, the hidden pictures test, and the two-hand coordination test.

The Thurstone-Gottschaldt test and the embedded figures test both use modifications of Gottschaldt's original figures. Thus it is not surprising that there should be a high relationship between performance on Witkin's test and performance on the Thurstone measure.

The hidden pictures test requires the subject to discover faces or other familiar figures hidden in a complex scene; for example, in trees or shrubbery. Witkin indicates that in past studies this test has not consistently loaded on the flexibility of closure factor. However, in his own research, he found that the test was related to the field dependence factor, though the relationship was not strong.

The two-hand coordination test requires the subject to tap a prearranged sequence in each of four segments of a circular plate, and to repeat the sequence as quickly as possible. Part of the test involves tapping separate patterns on different plates simultaneously. Witkin hypothesized that performance of this task would involve the analytical ability characteristic of field independence. He reports a study by

Podell and Phillips which indicates a significant relationship between the embedded figures test and the Thurstone two-hand coordination test.

Witkin concludes from results of the above studies that Thurstone's flexibility of closure factor and the field dependence factor measure essentially the same thing.

A second closure factor identified by Thurstone is speed of closure, which involves the identification of impoverished, i.e. incomplete, figures. Although field dependence was found to be related to flexibility of closure, it was not found to be related to speed of closure.

Field dependence has been shown to be related to perceptual constancy when two conditions are met: First, the constancy task must be designed so that the cues available for object judgments are not drastically reduced. Second, the subject must be instructed to adopt an analytical attitude in making his judgments. Witkin describes a study by Perez which illustrates the influence of the analytical attitude in size constancy judgments. Perez used two kinds of instructions: "look" instructions and "bet" instructions. In the "look" instructions condition, subjects were told to indicate size on the basis of the appearance of the object. In the "bet" instructions condition, subjects were asked to estimate the actual size of the object. A significant relationship was observed between the embedded figures test and constancy measured under the "look" instructions. Under the "bet" instructions, no significant relationship was found.

A finding of interest with respect to field dependence measures is that there are sex differences in performance on these measures. Women tend to display field dependence to a greater extent than men. This difference in performance between sexes has been widely demonstrated in cross-cultural investigations and developmental studies. Witkin indicates that differences have been observed consistently with children as young as 8 years old, though not below this age. Sex differences are also found consistently in adult life, but do not appear in the aged.

One explanation which Witkin offers for sex differences in field dependence is that women tend to be encouraged to adopt a more dependent

role than men in our culture. In support of this view, he reports that field dependence is correlated with performance on masculinity and femininity scales.

There is some evidence that field dependence measures may have relevance for school related tasks. Witkin, studying 10- and 12-year-olds, observed relationships between field dependence measures and full scale IQ's on the Wechsler Intelligence Scale for children. Factor-analytic studies revealed that the basis for these relationships involved three WISC Subtests: the Block Design, Object Assembly, and Picture Completion Subtests. Witkin suggests that all of these subtests include the necessity for overcoming an embedding context.

The results of the studies described above lend support to Witkin's hypothesis that the rod and frame test, body adjustment test, and embedded figures test measure field dependence. However, a large proportion of the variance in subjects' scores on these measures is not accounted for by the relationships among them.

Despite Witkin's extremely penetrating analysis of field dependence measures, it is difficult to determine what the defining features of field dependence are, and consequently difficult to establish why the relationships among field dependence measures are not higher. The structure of perception model could be used in a fashion analagous to that suggested with regard to speed of processing information to clarify the defining attributes of field dependence. A definition of field dependence could be selected in terms of the model and systematic variations introduced in the variables used to establish the definition. Changes in performance associated with changes in these variables would indicate the defining attributes of field dependence.

Shape and Size Constancy

Constancy and Reading. An essential task in the reading process is the achievement of visual percepts which correspond to the actual characteristics of the objects being perceived. This task is perhaps more directly related to object constancy than to any of the

other stimulus characteristics which describe perceptual experience.

Past research has indicated that in the face of marked alterations in the informational content which an object supplies to the sensory receptors, the object often appears to be relatively unchanged with respect to the various dimensions which define it (Holway and Boring, 1941; Brunswik, 1944). To explain this fact, Brunswik (1944), studying size constancy, suggested that size perception is the result of a probabilisti judgment based on cues emitted by the object and past experience.

Inability to make use of cues to achieve constancy would inject an intolerable degree of instability in the perception of objects and might easily affect a child's reading ability. For example, consider the effects of inadequate shape constancy on the reading process. If, while reading, a child were to shift the position of his book from directly in front of him either to the right or to the left, the images of the shapes of the letters on the child's retina would change. Letters which were approximately rectangular in shape would become trapezoidal. However, if the child had achieved adequate object constancy, the letters would not appear to be altered in shape. A child with inadequate shape constancy could experience serious difficulties in reading. Changes in the position of words with respect to the location of the child's eyes would be tantamount to changing the shapes of the words.

Developmental Studies of Constancy. It is known that children do not possess the degree of accuracy in perceptual constancy that is achieved in adults. Children require more cues to attain constancy than do older individuals. A study by Akshige (1937) in which extraneous perceptual cues were minimized demonstrates this. Akshige found an increase in shape constancy from the ages of four to ten. However, when additional perceptual cues were added, the age trend disappeared.

Evidence of the existence of size constancy in 9-month-old children has been obtained by Misumi (1951). However, as with shape constancy,

developmental changes do continue to occur throughout childhood (Beyrl, 1926). Cohen, Herskowitz, and Chodack (1958) suggest that improvement in size constancy may continue even longer. Their study indicated that young adults are more accurate in judging the size of objects than children when the object being judged is relatively far from the stimuli with which it is compared. However, their results do not indicate a developmental trend, i.e. a gradual improvement with age. Adults are superior to children, but there is no gradual improvement up to adulthood. In this connection it should be noted that the Cohen study did not involve any attempt to minimize perceptual cues available for making size judgments.

Ambiguities in the Definition of Constancy. The influence of cue minimization on perceptual constancy points to a problem of crucial importance in interpreting the results of constancy studies. When cues are not minimized, ambiguities in the definition of constancy arise. Specifically, it is often difficult to determine whether constancy refers to the appearance of objects or includes estimates or judgments of object characteristics. For example, consider an individual riding in an airplane several thousand feet above the earth observing a car below. If he were asked to judge the size of the car, he probably could make a reasonably accurate estimate. However, if he were asked to report how large the car looked, his estimate might be quite inaccurate. The view taken in this report is that the concept of perceptual constancy should be limited to refer to the appearance of characteristics.

The ambiguities in the definition of constancy have been illustrated in a number of studies. For example, Joynson and Newson (1962) did a study of shape constancy in which subjects were asked to select from a series of alternatives the shape which looked most like a standard. Supplementary subject reports revealed that for some subjects the above instructions were taken to mean, "Select the shape which actually is the same as the standard." For other subjects the instructions were interpreted to mean, "Select the shape which looks the same as the standard."

As task difficulty was increased more subjects became aware of the possibility of phenomenal judgments as opposed to judgments based on actual shape.

Joynson and Newson's findirgs suggest that there are cues in the perceptual situation which permit some subjects to choose between phenomenal and judgmental responses. It is important to know whether such cues are cognitive or perceptual. That is, does the subject base his judgments on a knowledge of the size of the standard stimulus which is independent of his perceptual judgment, or are the cues which are available to him only the various perceptual cues (convergence, retinal disparity, etc.) which are known to affect constancy.

In the typical constancy study, the perceiver has information which is other than perceptual about the size or shape of the objects which he is observing. In size constancy experiments the standard is typically placed at varying distances. The subject knows that he is observing the same standard at each of the distances. Similarly in shape constancy work, the standard is moved or rotated in space so that it is viewed at various angles, but the subject knows that he is viewing the same standard in all cases. Such knowledge could affect the subject's judgments.

The influence of cognitive cues can be minimized by interchanging the positions of the standard and variable stimuli. For example, in the typical shape constancy experiment, the standard stimulus is viewed at an angle, while the variable stimuli are viewed in the frontal plane. If the stimuli were interchanged, the subject would view the standard stimulus in the frontal plane, and the variable stimulus would be tilted.

The "interchange" approach was applied to size and shape measures used in the present project. Judgments under these conditions tended toward retinal size and shape. This finding will be discussed in detail in the discussion section of this report.

METHOD

Subjects

Fifty 2nd-grade children, 56 4th-grade children, and 56 6th-grade children participated in the study. The 2nd-grade children were randomly selected from four schools in a suburban school district in the midwest. There were 23 boys and 27 girls ranging in age from 7 years, 6 months to 7 years, 11 months. The 4th- and 6th-grade children were randomly selected from a school in a middle-class district in the southwest. There were 30 boys and 26 girls in the 4th-grade group ranging in age from 9 years, 5 months to 10 years, 10 months. In the 6th-grade group there were 29 boys and 27 girls ranging in age from 11 years, 5 months to 13 years, 3 months.

Testing for the 2nd-grade group was done in the spring of 1966. The California and Kuhlmann tests were given to the children in their regular classroom groups. All other tests were administered individually.

Tests were given in the following order: 1) Kuhlmann-Finch Intelligence Test, 2) California Reading Test, 3) speed of processing information test, 4) spatial orientation test, 5) Gates-McKillop Reading Test, 6) word reversal test, 7) size constancy test, and 8) shape constancy test.

Testing for the 4th- and 6th-grade groups was done in the spring of 1967. The Lorge-Thorndike and California tests were given to the children in their regular classroom groups. All other tests were administered individually.

The order of testing for the 4th- and 6th-grade groups was as follows: 1) spatial orientation test, 2) speed of processing information test, 3) Gates-McKillop Reading Test, 4) word reversal test, 5) reversed words in context test, 6) size constancy test, 7) shape constancy test, 8) California Reading Test, and 9) Lorge-Thorndike Intelligence Test.

Test Descriptions

Intelligence and Achievement Tests. The intelligence and the achievement tests were administered according to manual instructions. A subject's score for the achievement tests was the number of items correctly answered, and for the intelligence tests, the intelligence quotient.

The Gates-McKillop Test. The Gates test was administered individually according to the instructions in the manual. Only the oral paragraphs were used. A subject's score was the number of errors which he made on the first four paragraphs. Performance was tape recorded. Two judges scored performance from the tapes.

The Word Reversal Test. The subject's task was to read a list of 56 reversible words. He was instructed to guess if he were not sure of the pronunciation of a given word. His score was the number of words that he reversed subtracted from 56.

Reversed Words in Context Test. The 4th- and 6th-grade samples were given this task in addition to the word reversal task. The task involved 22 sentences, each containing one reversible word. The subject was required to read each sentence orally. His score was the number of reversible words that he reversed subtracted from 22.

Speed of Processing Information Test. For the speed of processing information test, the subject's task was to recognize words and phrases flashed on a screen and followed by interfering stimuli. The words and phrases were photographed from black 48 point lower case Ancient Egyptian Deca Dry Transfer type adhered to .005 Kodapak clear acetate. The acetate then was photographed over a clear white background by an Oxberry Animation Camera using 16mm Eastman Kodak Plux X reversal film with a light level of 250 ft. candle power falling upon

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[1]Instructions used for the perceptual tests, the word reversal test, and the reversed words in context test are given in Appendix A. Appendix B contains the response forms for the speed of processing information, word reversal, and reversed words in context tests.

the subject matter being photographed. To increase the contrast between lettering and background, the light was polarized at the source and again at the camera lens. This helped to strengthen the projected image on the screen so that it would replicate as closely as possible the printed word as it would appear to a person reading a book.

The 48 point lower case lettering was photographed with a 25mm lens used with a 16mm camera gate aperture of 9.65mm x 7.21mm at a distance sufficient to cover a 10" field of view at the 9.65 aspect.

A 16mm Kodak Analyst motion picture projector with synchronous motor set at 24 frames per second was used to present the stimuli. The children were seated approximately 76 inches from the screen on which the words were projected. Figure 5 presents the apparatus arrangement for the speed of processing information test.

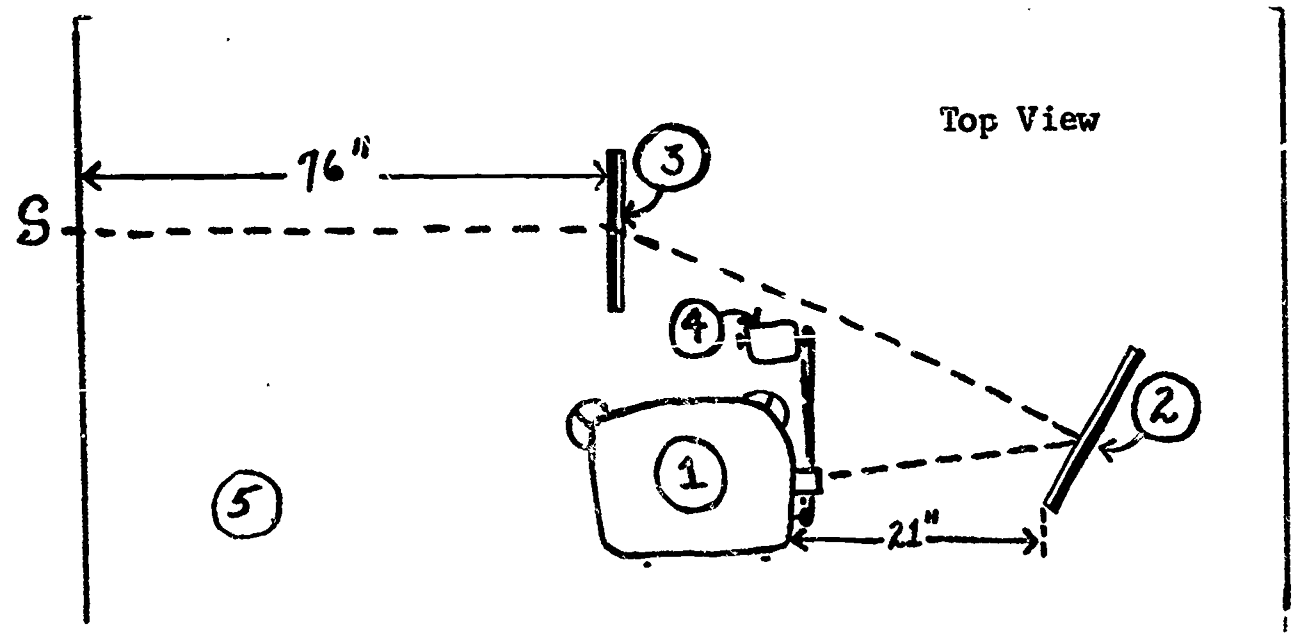

Figure 5

Speed of Processing Apparatus Diagram

(All Samples)

S - Subject; 1 - Projector; 2 - Mirror; 3 - Plexiglass Screen; 4 - Synchronous Motor; 5 - Table.

There were variations in procedure among the three grade levels which should be noted.[2] In the 2nd-grade group the subject was given three lists, the first containing single words, the second containing two-word phrases, and the third containing three-word phrases. His task on each trial was to select from five alternatives the stimulus which was the same as that projected. On the first 12 trials, single words were projected on the screen. On the next 10 trials, two-word phrases were used and on the last 10 trials three-word phrases were used.

In the 4th- and 6th-grade samples, the lists for the two-word phrases and three-word phrases consisted of two and three columns of words respectively. The subject was required to select the correct alternative from each column to receive credit for passing an item. For example, when a three-word phrase was flashed on the screen, the subject had to make three correct responses involving one alternative from each of three columns of words in order to receive credit.

Before each trial a dot appeared for two seconds at a point marking the center of the stimuli to follow. One second after the disappearance of the dot, the stimulus word or phrase was flashed on the screen. Immediately following the presentation of each stimulus, a combination of nonsense syllables two letters longer than the stimulus was presented. The subject was given 15 seconds to make his response. The exposure times for the stimulus words and phrases were in descending order: 7/24, 6/24, 5/24, 3/24, and 2/24 of a second. For the first four single-word trials, the exposure time was 7/24 of a second. Thereafter, each exposure time in the descending series was used for two trials. The series was repeated for the two-word phrases and for the three-word phrases. The subject's score was the number of words correctly identified.

Spatial Orientation Test. The task was to adjust to the apparent vertical a luminescent rod mounted inside a luminescent frame.

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[2]The changes made in measurement techniques represent attempts to increase the validity, reliability, and amount of information provided by the perceptual tests.

To insure that the concept of verticality was understood, before testing the experimenter tilted a pencil to the left and asked the subject to make it "straight up and down like the walls of the room or like a flagpole." If the subject responded correctly the pencil was tilted to the right and the question repeated. If the child responded incorrectly the experimenter demonstrated the correct response. This procedure was repeated three times, once with the subject's head tilted to the left, once with his head held upright, and once with his head tilted to the right. All of the subjects were able to adjust the pencil properly.

Testing was carried out in a dark room. The subject's eyes were covered with a mask which was removed only when he was adjusting the rod. The subject was seated in a tilted position in a Witkin chair and instructed to adjust the position of the luminescent rod so that it appeared vertical. For the 2nd-grade group two buttons, one mounted on each side of the chair, controlled the direction of movement of the rod. For the 4th- and 6th-grade groups a single toggle switch on the right arm of the chair was used. On each trial the rod, the frame, and the chair were placed at one of two positions of tilt, 30° left or 30° right. There were 16 trials. The positions of the rod, frame, and chair are given for each trial in Table 1.

TABLE 1

ROD, FRAME, AND CHAIR POSITIONS

	Rod	Frame	Chair		Rod	Frame	Chair
1.	R	R	R	9.	L	L	L
2.	L	R	L	10.	L	R	L
3.	L	L	R	11.	L	L	L
4.	R	L	R	12.	L	L	R
5.	R	R	L	13.	R	L	R
6.	R	L	L	14.	R	L	L
7.	R	R	L	15.	L	R	R
8.	L	R	R	16.	R	R	R

R = right, L = left.

The subject's score on each trial was the absolute difference between the position of the adjusted rod and the objective vertical rendered in degrees. A total score for each subject was determined by adding the scores for each trial.

Figure 6 shows the apparatus arrangement for the spatial orientation test.

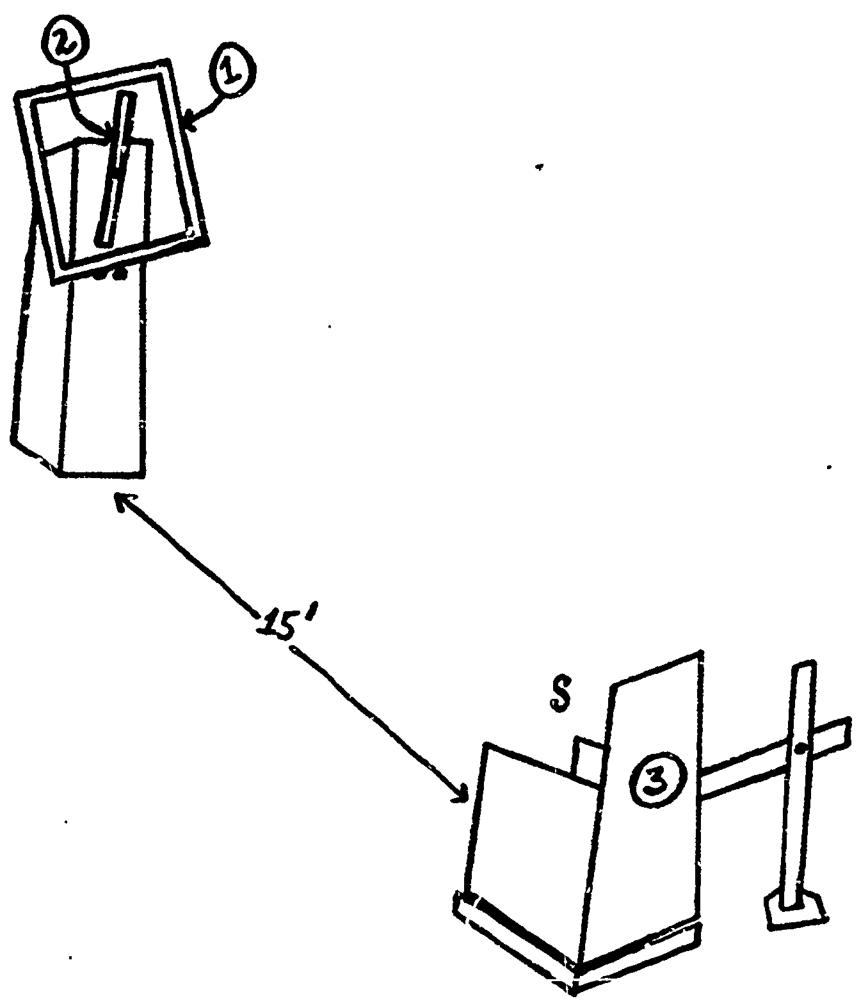

Figure 6

Spatial Orientation Apparatus Diagram

(All Samples)

S - Subject; 1 - Frame; 2 - Rod; 3 - Tilted Chair.

Size Constancy Test. The subject's task on the size constancy test was to match the si of a variable circle to that of a standard. The variable circle was a 1.80 inch disc cut from white cardboard. This disc was made to appear to change in size from 1 to 10 inches at a constant rate of expansion within a period of 10 seconds. This effect was achieved by matching the disc center with the optical center of the camera lens.

To achieve the expansion the camera was made to approach the disc taking one picture for each of a series of successively shorter camera positions. The disc was photographed over a middle gray card background. A co[illegible] of a frame from this film was used for the standard stimulus. Figure 7 shows the apparatus arrangement for the 2nd-grade group.

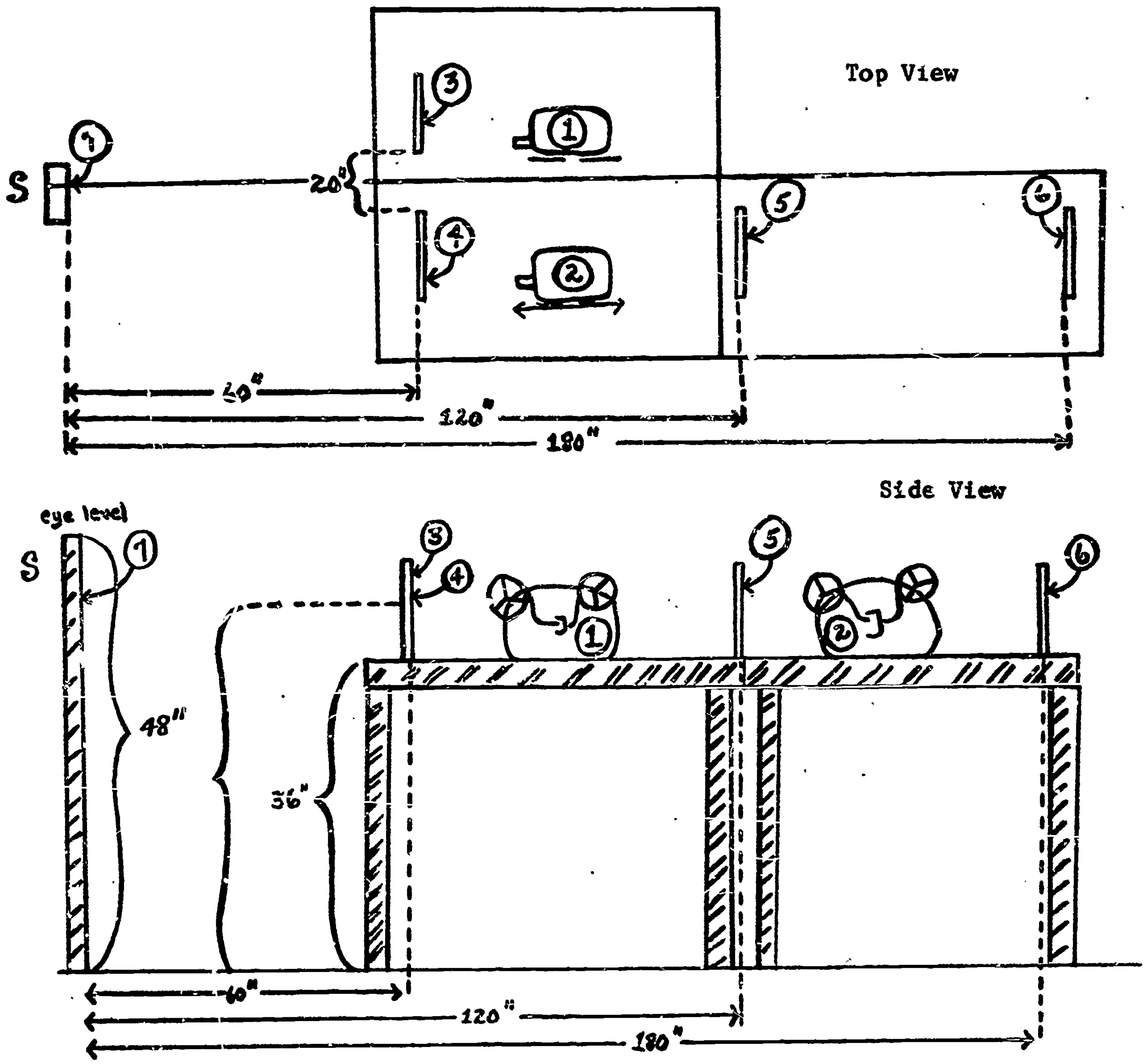

Figure 7

Size Constancy Apparatus Diagram

(2nd Grade)

1 and 2 are projectors; 3 - 6 are plexiglass screens; 7 is the chin rest.

Figure 8 shows the apparatus arrangement for the 4th- and 6th-grade groups.

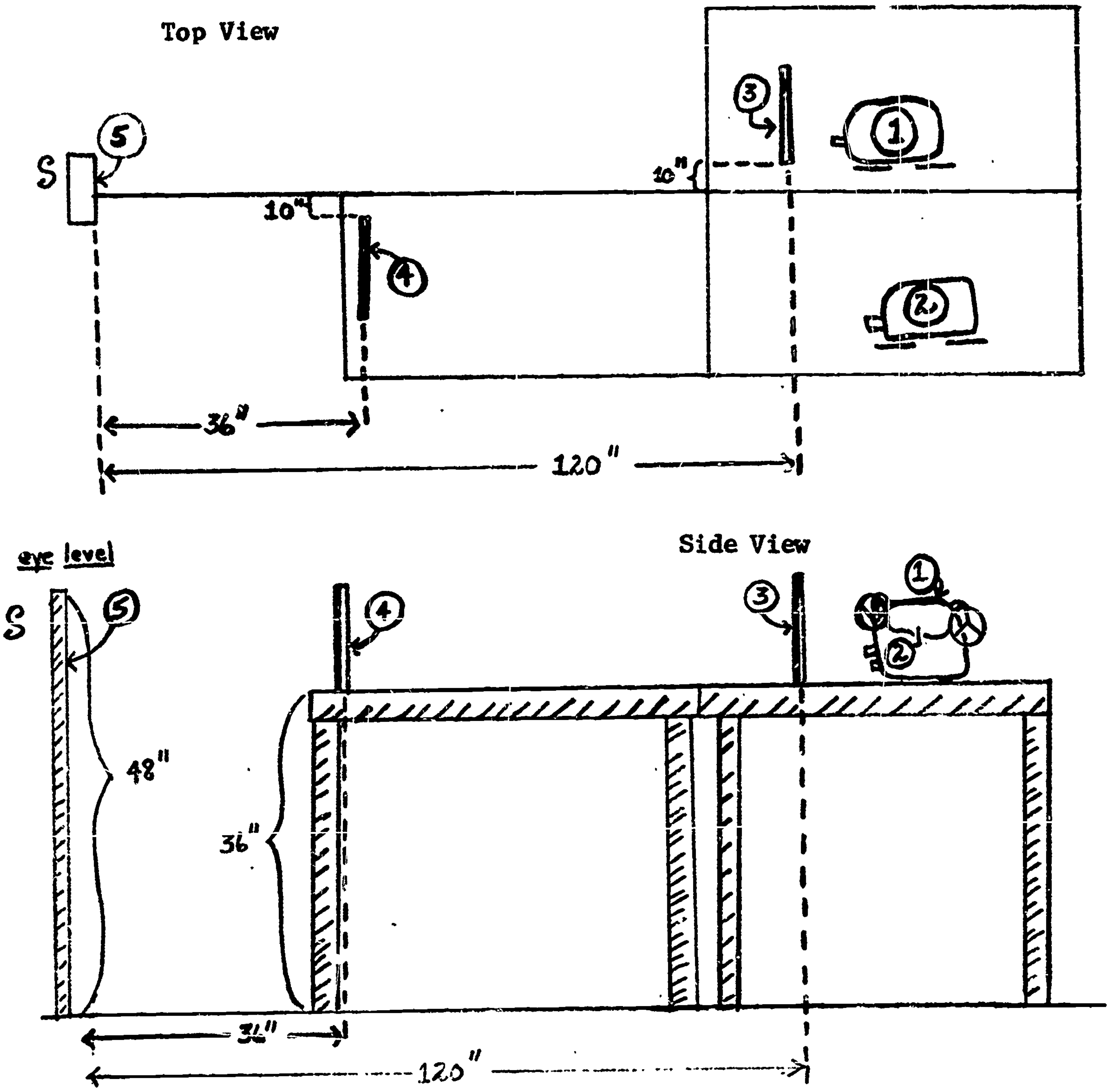

Figure 8

Size Constancy Apparatus Diagram

(4th & 6th Grade)

1 and 2 are projectors; 3 and 4 are plexiglass screens; 5 is the chin rest.

In the 2nd-grade sample, the 5 inch standard circle was projected on a translucent screen 5, 10, or 15 feet in front of the subject. The variable was projected 5 feet from the subject and slightly to the left of the line of sight parallel to the frontal plane. The size of the variable at the beginning of each trial was alternately 10 inches and 1 inch. The experimenter advanced the film a frame at a time until the subject indicated verbally that the two circles were equal in size. There were 15 trials, five at each of the three distances. The order of distance presentation is given in Table 2.

Table 2

Size Constancy Distance for Fourth Grade

Trial	Feet	Trial	Feet	Trial	Feet
1.	5	6.	10	11.	5
2.	15	7.	15	12.	10
3.	15	8.	15	13.	5
4.	15	9.	10	14.	5
5.	10	10.	5	15.	10

In the 4th- and 6th-grade groups, the variable was presented at 10 feet and the standard at 3 feet and to the left of the line of sight. The film was advanced continuously rather than a frame at a time, and there were 12 trials.

The changing of the positions of the variable and standard stimuli for the 4th- and 6th-grade groups represents an important alteration in procedure. The 2nd-grade children knew that they were seeing the same standard in different positions. Thus, they had information which was other than perceptual about the size of the standard. The alterations introduced for the 4th- and 6th-grade groups were intended to minimize the influence of cognitive cues on size judgment.

The scoring for the size and shape constancy tests was complicated to a degree by the presence of a constant error associated with variable stimulus adjustment. When the initial diameter of the variable stimulus was 10 inches, the subject's judgments tended to be greater than when the initial size of the variable was 1 inch. The following formula given by Guilford (1954) was used to assess the magnitude of constant error for each subject:

$$CE = \frac{\overline{L} - \overline{S}}{2},$$

where CE = constant error, $\overline{L}$ = the mean of trials in which the initial diameter of the variable was 10 inches, and $\overline{S}$ = the mean of trials in which the initial diameter of the variable was 1 inch. A subject's score (S) for the size constancy test is given by the formula:

$$S = \frac{\Sigma(X_i\text{-D-CE})}{N},$$

where X_i = a subject's judgment on a given trial, D = the diameter of the standard, and CE = the constant error.

Shape Constancy Test. The subject's task on the shape constancy test was to match the shape of a variable ellipse presented in the horizontal plane to that of a standard circle presented in the vertical plane. The variable stimulus was an ellipse made from white cardboard. The ellipse was laid with the narrow side over the center of a board. This board was tilted on a central axis so that when viewed through the camera with an appropriate lens F-stop, the ellipse when tilted down became in effect a sharply defined circle. The photograph was taken directly over black velvet and a Kodak middle gray card was selected to superimpose as a background. A copy of the frame from this film was used for the standard stimulus.

A diagram of apparatus arrangement for the shape constancy task is given in Figure 9, Page 50. The top half of the figure gives a top view of the apparatus including distances from the subject to the

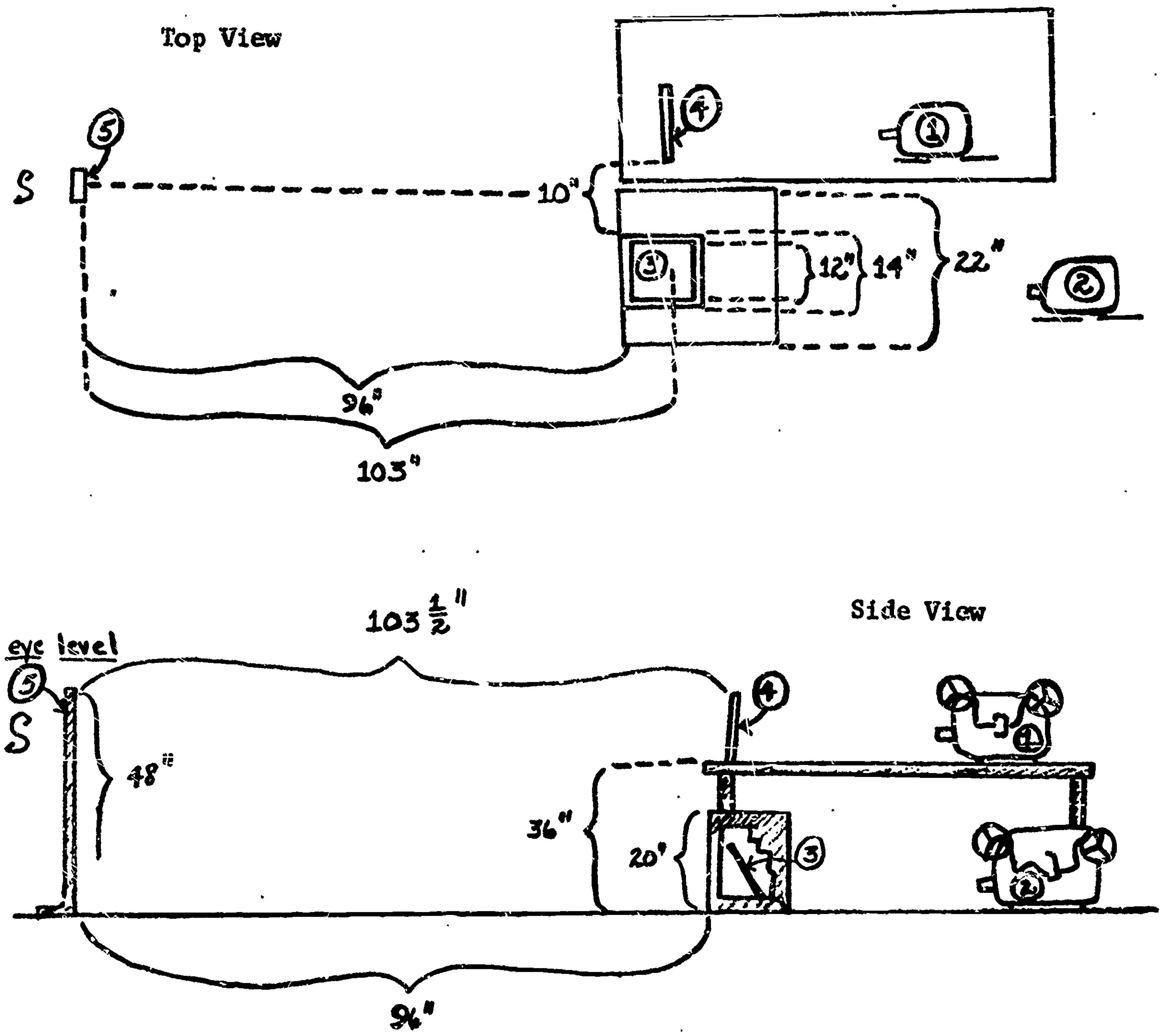

Figure 9

Shape Constancy Apparatus Diagram

(All Samples)

1 and 2 are projectors; 3 and 4 are plexiglass screens; 5 is the chin rest.

standard and variable stimulus. The bottom half of the figure is a side view representation of apparatus arrangement.

The elliptical image was projected on a horizontal translucent screen positioned 8 feet from the subject and 28 inches below his eyes. A 5 inch standard circle was projected 8 feet from the subject to the left of the line of sight and parallel to the frontal plane. At the beginning of each trial, the diameter of the projected ellipse was alternately 10" and 1". There were 12 trials. The score for each subject was computed in the same fashion as that for the size constancy test.

In the 2nd-grade group, the experimenter advanced the film a frame at a time until the subject indicated verbally that the shape of the variable matched that of the standard. In the 4th- and 6th-grade samples the experimenter advanced the film continuously until the subject made his judgment. The adjusted diameter of the projected ellipse was taken as the subject's score on each trial. His total score was computed in the same fashion as for the size constancy test.

RESULTS

Tables 3 and 4 show the means and standard deviations for all tests used in the project.

TABLE 3

MEANS AND STANDARD DEVIATIONS OF TEST SCORES FOR SECOND GRADE

Test	M	S.D.
VF/P_tRS (Speed)	9.96	4.95
$VP_s/RAmF$ (Position)	20.76	9.23
VM/P_sAmF (Size)	.05	.06
VF/P_sAmF (Shape)	.55	.36
Kuhlmann-Finch	112.82	11.49
Gates-McKillop	11.32	9.26
Word Reversal	52.62	1.95
California Reading Test		
Word Recognition	16.84	2.67
Meaning Opposites	17.96	4.67
Interpretation Materials	17.16	4.98
Word Form	22.22	2.34
Total	73.98	12.00
C.E. (Size)	.56	.96
C.E. (Shape)	.73	.12

TABLE 4

MEANS AND STANDARD DEVIATIONS OF TEST SCORES FOR THE FOURTH AND SIXTH GRADES

Test	Fourth M	Fourth S.D.	Sixth M	Sixth S.D.
VF/P_tRS (Speed)	16.14	5.78	11.14	5.48
$VP_s/RAmF$ (Position)	20.10	10.13	14.90	10.16
VM/P_sAmF (Size)	.92	.68	.71	.49
VF/P_sAmF (Shape)	1.35	.56	1.48	.44
Lorge-Thorndike				
Verbal	107.55	14.24	108.41	14.64
Non-Verbal	107.77	13.99	109.07	12.47
Total	107.88	12.66	109.00	12.17
Gates-McKillop	18.61	13.34	8.71	5.41
Word Reversal	54.93	1.25	55.36	.83
Reversals--Context	20.57	2.46	21.21	2.66
California Reading Test				
Reference Skills	12.29	3.72	16.73	2.26
Reading Vocabulary	33.61	8.04	43.11	5.33
Interpretation Materials	15.59	4.42	21.32	4.98
Following Directions	14.39	4.01	17.68	2.26
Total	75.39	17.03	98.84	12.29
C.E. (Size)	.17	.28	.15	.34
C.E. (Shape)	.15	.34	.11	.24

Scores for the perceptual tests and the Gates-McKillop Test are reported as error scores. The scores reported for intelligence tests are I.Q.'s, while those for the remaining tests are raw scores. The means and standard deviations of the size constancy test and the speed of processing test for the second grade are not comparable to those of the fourth and sixth grade because of variations in procedure between grades.

Reliabilities are reported in Table 5. The reliabilities for the perceptual tests, the reversed words in context test, and word reversal test were computed using the Rulon formula (Guilford, 1954). Spearman's rho was used to compute interrater reliabilities for the Gates-McKillop

Reading Test (Siegel, 1956).

TABLE 5

RELIABILITY COEFFICIENTS

PERCEPTUAL AND READING TESTS

Test	No. of Items	Procedure	Grade Second r	Fourth r	Sixth r
VF/P_tRS (Speed)	32	Rulon	.96	.91	.89
VP_s/RAmF (Position)	16	Rulon	.89	.89	.91
VM/P_sAmF (Size)	12	Rulon	.79	1.00	.91
VF/P_sAmF (Shape)	12	Rulon	.94	.97	.95
Word Reversal	56	Rulon	.37	.29	-.06
Word Reversal, Context	22	Rulon	--[b]	.22	-.12
Gates-McKillop	--[a]	rho	.99	1.00	1.00

[a]The first four paragraphs were used. [b]Not given.

Reliabilities for the reversed words in context and word reversal tests were quite low. The children in all grades had virtually no difficulty in recognizing reversible words accurately. Table 6 shows the number of subjects whose mean judgments were below the diameter of the standard stimulus.

TABLE 6

NUMBER OF SUBJECTS UNDER-ESTIMATING THE STANDARD STIMULUS

FOR THE SIZE AND SHAPE CONSTANCY TESTS

Test	Grade Second	Fourth	Sixth	Total
Size Constancy	22	1	5	28
Shape Constancy	0	0	1	1

In order to determine the extent to which the perceptual measures under study could be considered to represent separate abilities and to establish the relationship of the perceptual measures to reading achievement, three principle components factor analyses, one for each of the three participating grades, were performed (Harman, 1960). Tables 7, 8, and 9, pages 56, 57, and 58, present the intercorrelation matrices used in these analyses for grades two, four, and six, respectively. The intercorrelations of the perceptual tests were low, and in almost all instances, not significant. Speed of processing information correlated significantly with intelligence and achievement scores at all grades. Size constancy was significantly related to the Word Recognition Subtest of the California Achievement Test at 2nd-grade level and to a number of achievement measures at the 4th-grade level. Spatial orientation was related to achievement and I.Q. in the 4th-grade sample. In both the 4th- and 6th-grade samples, spatial orientation was related to size constancy, a finding which corresponds to results reported by Witkin. Scores on the spatial orientation test for the 4th- and 6th-grades were significantly correlated with sex. The relationship approached significance for the 2nd-grade group. Males tended to be more accurate than females in judging position in space, which is consistent with research findings of Witkin and his colleagues (Witkin, 1962). The constant errors associated with adjustment of the variable stimulus on the shape and size constancy tests for the most part were not related to each other or to other measures in the battery. Despite their unreliability, the word reversal and reversed words in context tests were significantly related to achievement measures in both the 4th- and 6th-grade groups; however, in the 6th-grade group the relationship was less substantial.

Principle axes solutions for the 2nd-, 4th-, and 6th-grade groups are reported in Tables 10, 11, and 12, pages 59 and 60.

TABLE 7

MATRIX OF INTERCORRELATIONS FOR SECOND GRADE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
VF/P_tRS (Speed)	--													
VP_s/RAmF (Position)	.04	--												
VM/P_sAmF (Size)	.10	.07	--											
VF/P_sAmF (Shape)	.00	.01	.06	--										
Kuhlman-Finch	*.48	.24	.19	-.12	--									
Gates-McKillop	*.40	.01	.25	-.06	.22	--								
Word Reversal	*.46	.08	.10	.10	.14	*.35	--							
Word Recognition	*.43	.10	.25	-.24	*.34	*.65	*.28	--						
Meaning Opposites	*.56	.18	*.42	-.09	*.49	*.59	*.42	*.76	--					
Interpret. Materials	*.45	.04	-.00	-.16	*.48	*.37	*.41	*.57	*.66	--				
Word Form	*.39	-.04	.09	-.12	*.35	.26	*.27	*.42	*.41	.17	--			
Calif. Total	*.58	.11	.26	-.16	*.55	*.63	*.46	*.84	*.93	*.81	*.53	--		
C. E. (Size)	-.16	-.22	*.44	-.17	*.32	-.12	-.12	-.14	-.19	-.09	-.26	-.15	--	
C. E. (Shape)	.09	-.02	.28	-.12	.15	*.28	-.08	-.21	*.27	.01	-.17	-.19	.02	--
Sex	*.37	-.23	-.00	-.13	.08	*.38	.17	*.35	*.41	.26	.10	*.39	.07	.10

*Significant at .05 level

For some tests represented in the correlation and factor matrices a subject's score was the number of correct responses. For other tests error scores were used. High ability for the former is indicated by a high score. For the latter high ability is indicated by a low score. The signs of correlation coefficients and factor loadings have been changed to reflect correspondence between abilities rather than between test scores.

TABLE 3

MATRIX OF INTERCORRELATIONS FOR FOURTH GRADE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	--																	
2.	*.33	--																
3.	.21	.02	--															
4.	-.25	-.06	*.28	--														
5.	*.66	*.34	.14	-.17	--													
6.	*.43	.25	.22	-.19	*.63	--												
7.	*.61	*.34	.20	-.21	*.90	*.90	--											
8.	*.45	*.32	.06	.00	*.69	*.40	*.60	--										
9.	*.32	.05	.09	.12	*.47	.22	*.38	*.42	--									
10.	.22	.15	.07	-.11	*.42	*.45	*.48	*.46	.24	--								
11.	*.36	.15	.18	-.19	*.58	*.53	*.60	*.48	.10	*.50	--							
12.	*.46	*.34	.19	-.20	*.74	*.61	*.74	*.59	*.39	*.46	*.56	--						
13.	*.59	*.33	*.30	-.07	*.71	*.55	*.70	*.52	*.37	*.30	*.49	*.58	--					
14.	*.44	*.32	*.28	-.21	*.67	*.52	*.65	*.47	.21	*.47	*.73	*.70	*.52	--				
15.	*.55	*.35	*.27	-.20	*.82	*.67	*.82	*.63	*.35	*.51	*.78	*.91	*.77	*.86	--			
16.	-.07	*-.45	-.02	.06	-.07	.08	.09	.00	.05	.09	.05	.06	-.19	.07	.01	--		
17.	-.12	-.24	.17	.18	-.30	-.23	*-.28	-.20	-.09	.01	-.07	-.18	-.03	-.11	-.13	*.40	--	
18.	-.04	-.14	*-.48	-.12	-.04	-.08	-.06	-.00	.01	*.10	-.14	-.02	-.19	-.18	-.13	*.30	.06	--
19.	-.02	-.18	*-.27	*-.52	-.10	-.07	-.09	-.21	-.04	*-.32	-.15	-.12	-.16	-.[illegible]	-.16	.11	-.00	.26

*Significant at .05 level

Variables

1. VF/P_tRS (Speed)
2. VP_s/RAmF (Position)
3. VM/P_sAmF (Size)
4. VF/P_sAmF (Shape)
5. L.-T. VIQ
6. L.-T. NVIQ
7. L.-T. TIQ
8. Gates-McKillop
9. Word Reversal
10. Word Reversal--Context
11. Reference Skills
12. Reading Vocabulary
13. Interpretation Materials
14. Following Directions
15. California Total
16. Sex
17. Age
18. C. E. (Size)
19. C. E. (Shape)

TABLE 9

MATRIX OF INTERCORRELATIONS FOR SIXTH GRADE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	--																	
2.	.12	--																
3.	-.15	*.30	--															
4.	.19	.11	.02	--														
5.	*.56	.09	-.19	-.06	--													
6.	*.29	.21	-.12	-.07	*.63	--												
7.	*.48	.16	-.18	-.07	*.92	*.89	--											
8.	*.63	-.04	*-.29	-.04	*.53	.27	*.45	--										
9.	*.28	.07	.11	.15	.25	*.31	*.31	*.41	--									
10.	.04	.12	.01	.16	-.12	-.26	-.20	.01	.13	--								
11.	*.47	.21	-.15	.02	*.48	*.47	*.52	*.39	.21	.04	--							
12.	*.51	.02	-.26	-.07	*.68	*.58	*.70	*.65	*.33	-.13	*.33	--						
13.	*.55	.03	-.08	.10	*.72	*.56	*.72	*.52	*.27	-.18	*.41	*.66	--					
14.	*.45	.02	-.17	-.10	*.62	*.48	*.62	*.46	.17	*-.36	*.44	*.64	*.70	--				
15.	*.61	.06	-.21	-.01	*.79	*.65	*.80	*.65	*.32	-.19	*.57	*.88	*.89	*.82	--			
16.	.24	*-.31	-.16	-.08	.24	-.02	.13	.15	-.20	-.13	.18	.20	.17	*.41	.26	--		
17.	-.19	-.12	.00	.15	*-.38	*-.39	*-.42	.07	-.05	*.31	-.10	-.22	-.24	-.24	-.25	-.13	--	
18.	-.05	.07	-.21	.18	-.09	-.11	-.11	.06	.10	.09	.16	-.07	.05	-.05	.01	-.12	.13	--
19.	.23	.01	.09	-.20	.28	.04	.19	-.02	-.13	-.17	-.05	.04	.18	.11	.10	.09	-.25	.24

*Significant at .05 level.

Variables

1. VF/P_tRS (Speed)
2. $VP_s/RAmF$ (Position)
3. VM/P_sAmF (Size)
4. VF/P_sAmF (Shape)
5. L.-T. VIQ
6. L.-T. NVIQ
7. L.-T. TIQ
8. Gates-McKillop
9. Word Reversal
10. Word Reversal--Context
11. Reference Skills
12. Reading Vocabulary
13. Interpretation Materials
14. Following Directions
15. California Total
16. Sex
17. Age
18. C. E. (Size)
19. C. E. (Shape)

TABLE 10

PRINCIPAL AXES SOLUTION FOR SECOND GRADE

Variables	I	II	III	IV	V	VI	VII
VF/PtRS (Speed)	-.69	-.05	-.27	.10	-.05	.28	-.30
VP_s/RAmF (Position)	-.13	.55	-.03	-.12	.07	.28	.61
VM/P_sAmF (Size)	-.34	.47	.56	.46	-.02	-.11	-.14
VF/P_sAmF (Shape)	.17	-.07	.36	.12	-.33	.78	-.13
Kuhlmann-Finch	-.59	.39	-.39	.09	-.41	.05	.01
Gates-McKillop	-.69	-.33	.28	.02	-.06	-.02	.17
Word Reversal	-.53	-.07	.01	-.11	.58	.51	-.20
Word Recognition	-.83	-.09	.09	-.08	-.02	-.22	.19
Meaning Opposites	-.92	.02	.13	.09	-.05	.01	.12
Interpretation Materials	-.73	-.12	-.31	.06	.11	.08	.23
Word Form	-.54	.14	.00	-.60	-.20	-.11	-.47
California Total	-.97	-.05	-.03	-.06	-.04	-.02	.10
C. E. (Size)	.25	-.77	-.00	-.12	-.25	.17	.31
C. E. (Shape)	.20	.05	-.80	.28	-.02	.09	-.08
Sex	-.44	-.53	-.03	.37	.05	-.20	-.17

TABLE 11

PRINCIPAL AXES SOLUTION FOR FOURTH GRADE

Variables	I	II	III	IV	V	VI	VII	VII	IX
VF/P_tRS (Speed)	.67	-.40	-.09	.02	.12	-.29	.38	.12	-.03
VP_s/RAmF (Position)	.43	.30	.14	-.14	-.07	-.51	-.18	.54	-.15
VM/P_sAmF (Size)	.27	.08	.66	.38	.13	.09	.27	-.16	-.04
VF/P_sAmF (Shape)	-.20	.06	.71	-.43	.04	.08	.05	-.25	-.30
L.-T. VIQ	.90	-.10	-.11	-.13	-.02	.05	.15	.05	-.09
L.-T. NVIQ	.76	.15	-.08	.12	.47	.25	-.05	.05	-.07
L.-T. TIQ	.92	.03	-.11	-.01	.26	.15	.06	.06	-.09
Gates-McKillop	.72	-.19	-.01	-.38	-.23	-.06	-.02	-.06	.00
Word Reversal	.43	.22	.02	-.51	-.18	.17	.52	-.15	.33
Word Reversal--Context	.57	.04	-.02	-.18	.18	.02	-.46	-.31	.45
Reference Skills	.73	-.18	-.02	.28	-.15	.06	-.31	-.20	.02
Reading Vocabulary	.85	.25	-.10	-.03	-.14	.02	-.03	-.11	-.12
Interpretation Materials	.78	-.07	.15	.04	.11	-.21	.27	.05	.06
Following Directions	.80	.09	.00	.28	-.27	-.02	-.18	-.13	-.08
California Total	.95	.08	-.01	.12	-.13	-.03	-.05	-.11	-.06
Sex	-.08	-.03	-.24	.03	-.12	.06	.06	-.83	-.26
Age	-.23	.12	.17	.23	.12	-.54	.14	-.65	.16
C. E. (Size)	-.14	.03	-.65	-.43	.27	-.19	-.09	-.28	-.22
C. E. (Shape)	-.19	.21	-.71	.34	-.09	.02	.39	.10	.01

TABLE 12

PRINCIPAL AXES SOLUTION FOR SIXTH GRADE

Variables	I	II	III	IV	V	VI	VII	VIII	IX
VF/PtRS (Speed)	.68	-.15	-.10	-.09	-.01	.20	-.14	.48	.03
VP_s/RAmF (Position)	.09	-.40	.71	.09	.10	.25	.13	.03	.14
VM/P_sAmF (Size)	-.23	.02	.62	-.12	.24	-.08	.30	.34	-.43
VF/P_sAmF (Shape)	-.03	-.27	.01	.16	-.46	.54	-.30	.20	-.49
L.-T. VIQ	.88	-.02	.07	.05	-.08	-.09	-.06	.07	.15
L.-T. NVIQ	.74	.08	.36	.07	-.24	-.07	.06	-.35	.07
L.-T. TIQ	.90	.03	.22	.07	-.18	-.09	.00	-.14	.13
Gates-McKillop	.68	.22	-.27	-.10	.16	.31	-.10	.20	.06
Word Reversal	.37	.50	.24	-.38	.09	.50	-.05	.05	-.16
Word Reversal--Context	-.22	.03	-.03	-.04	-.17	.57	.18	.38	.48
Reference Skills	.60	-.40	.02	-.18	.05	.27	.30	-.07	.20
Reading Vocabulary	.83	.26	-.11	.12	.01	.05	.05	-.04	.01
Interpretation Materials	.84	-.03	-.01	.20	.12	.05	-.08	.05	-.22
Following Directions	.79	-.10	-.17	.06	.18	-.17	.19	-.08	-.23
California Total	.96	.01	-.08	.11	.09	.06	.08	-.02	-.09
Sex	.27	-.30	-.57	-.30	-.13	-.36	.29	.21	-.16
Age	-.38	.11	-.31	.52	.22	.44	.34	.12	-.03
C. E. (Size)	-.05	-.35	-.18	-.13	.41	.52	-.34	-.43	-.01
C. E. (Shape)	.18	-.09	.16	.14	.27	-.52	-.41	.49	.21

Varimax rotations for each analysis were carried out and are presented in Tables 13, 14, and 15, pages 61 and 62. K/2 factors were rotated in the analyses, K equalling the number of tests analyzed. Verbal skills factors comprised of achievement and intelligence measures emerged at all grade levels. Separate size and shape constancy factors emerged at all three grade levels.

With the exception of size constancy and the constant error for shape constancy in the 4th grade, no other tests loaded on shape constancy factors. In the 2nd and 4th grades, separate factors emerged for the spatial orientation test. In the 6th-grade sample, spatial orientation combined with size constancy to form a factor. Speed of processing information emerged as a separate factor at the 4th-grade level. In the 2nd and 6th grades, this test had its highest loading on the verbal skills factor.

Multiple linear regression analyses for each of the three grades were computed to determine the proportion of variance which each of the

TABLE 13

VARIMAX ROTATION FOR SECOND GRADE

Variable	I	II	III	IV	V	VI	VII	h^2
VF/P_tRS (Speed)	*.54	.09	*.41	.17	-.18	-.28	*.37	.73
$VP_s/RAmF$ (Position)	.16	.10	.03	.01	*.85	.13	.05	.79
VM/P_sAmF (Size)	.25	*.86	-.21	.16	-.03	.07	-.07	.88
VF/P_sAmF (Shape)	-.13	-.02	-.06	*.94	.04	.05	.09	.91
Kuhlmann-Finch	*.53	.23	*.57	.06	.23	*-.31	-.15	.83
Gates-McKillop	*.76	-.04	-.28	.07	-.15	-.02	.08	.69
Word Reversal	*.30	.04	-.02	.10	.02	-.10	*.90	.93
Word Recognition	*.84	.08	-.14	-.21	.00	-.18	.05	.80
Meaning Opposites	*.89	.25	-.03	.02	.03	-.13	.16	.89
Interpret. Materials	*.73	-.09	.26	-.15	.08	.02	.28	.72
Word Form	.28	.07	-.05	-.06	-.06	*-.91	.11	.94
California Total	*.92	.09	.04	-.08	.02	-.26	.20	.96
C. E. (Size)	-.21	-.16	*.82	-.14	-.03	.16	.02	.78
C. E. (Shape)	.04	*-.79	-.18	.26	-.19	.25	-.18	.86
Sex	*.49	-.02	.05	-.08	*-.63	.16	.09	.69

*Factor loading above .30

TABLE 14

VARIMAX ROTATION FOR FOURTH GRADE

Variable	I	II	III	IV	V	VI	h^2
VF/P_tRS (Speed)	*.34	*.83	-.10	.02	.16	.12	.87
$VP_s/RAmF$ (Position)	*.30	.10	.08	-.03	.03	*.90	.92
VM/P_sAmF (Size)	.18	.10	*.31	*.65	*.32	-.08	.79
VF/P_sAmF (Shape)	-.18	-.13	*.88	.07	-.01	-.04	.89
L.-T. VIQ	*.67	*.47	.00	-.04	.28	.09	.89
L.-T. NVIQ	*.48	.16	-.05	.03	*.78	.05	.92
L.-T. TIQ	*.63	*.35	-.03	-.02	*.59	.10	.97
Gates-McKillop	*.59	*.38	.20	-.14	-.08	.10	.76
Word Reversal	.18	.14	.05	.00	.07	*.03	.94
Word Reversal--Context	*.42	.01	.07	-.12	.20	.02	.91
Reference Skills	*.79	.17	-.04	.14	.07	-.11	.81
Reading Vocabulary	*.82	.08	-.01	-.06	.26	.15	.84
Interpretation Materials	*.47	*.55	.03	.20	*.30	.22	.77
Following Directions	*.89	.08	-.07	.16	.09	.08	.86
California Total	*.89	.24	-.02	.10	.24	.12	.96
Sex	.26	-.13	.08	*-.37	-.11	*-.65	.85
Age	-.11	.00	.05	.00	-.11	-.13	.92
C. E. (Size)	-.10	.01	-.09	*-.91	.09	-.10	.87
C. E. (Shape)	-.09	-.07	*-.80	-.18	.04	-.12	.87

*Factor loading above .30

TABLE 15

VARIMAX ROTATION FOR SIXTH GRADE

Variable	I	II	III	IV	V	VI	VII	VIII	IX	h^2
VF/P_tRS (Speed)	*.57	.29	-.01	.26	-.06	*.31	*.37	.06	.27	.79
$VP_s/RAmF$ (Position)	.19	*.36	*.61	-.23	-.14	*.36	.02	.19	.08	.78
VM/P_sAmF (Size)	-.21	-.04	*.88	.15	.03	-.12	.06	-.21	.01	.90
VF/P_sAmF (Shape)	-.02	-.03	.03	.04	.05	.06	-.10	.08	*.97	.97
L.-T. VIQ	*.84	.06	-.10	.05	-.24	.10	.21	-.07	-.01	.83
L.-T. NVIQ	*.78	-.25	.01	-.04	*.38	-.03	-.21	-.13	-.06	.88
L.-T. TIQ	*.90	-.10	-.05	.01	*.33	.05	.01	-.11	-.04	.94
Gates-McKillop	*.58	.17	-.23	*.51	.12	.16	.16	.14	.02	.77
Word Reversal	.27	-.19	.15	*.83	-.09	.10	-.17	.05	.07	.87
Word Reversal--Context	-.22	-.08	-.07	.16	.23	*.81	-.03	-.05	.10	.81
Reference Skills	*.59	.25	.15	-.06	-.12	*.42	-.17	*.32	-.06	.77
Reading Vocabulary	*.83	.03	-.19	.26	.04	-.04	.01	-.09	-.06	.80
Interpretation Materials	*.84	.08	.03	.12	.04	-.16	.17	.09	.16	.82
Following Directions	*.79	*.35	.06	.01	.03	-.24	.01	.08	-.09	.83
California Total	*.95	.16	-.03	.15	.02	-.05	.04	.07	.01	.97
Sex	.16	*.90	-.12	-.12	-.07	-.04	.01	-.10	-.03	.88
Age	-.20	-.08	-.02	-.05	*.89	.14	-.16	.03	.06	.90
C. E. (Size)	-.06	-.10	-.12	.06	.05	.01	-.11	*.93	.09	.91
C. E. (Shape)	.10	-.01	.06	-.12	-.15	.06	*.89	-.14	-.14	.38

*Factor loading above .30

perceptual measures contributed to the relationship between perception and reading (Efroymson, 1960). The independent variables in these analyses were the four perceptual tests. Total achievement scores were used as the dependent variables.

The results of the multiple linear regression analyses are presented in Table 16. In all three analyses, speed of processing information accounted for the most variance; however, spatial orientation and size constancy did add to the variance. The multiple correlations between perceptual tests and achievement were of substantial magnitude (in the .60's) for all grades. (See Table 16, Page 63).

To determine the effects of reading achievement, speed of stimulus presentation, and amount of information presented on information processing, a three factor analysis of variance with repeated measures on the last two

TABLE 16

MULTIPLE LINEAR REGRESSION WITH TOTAL ACHIEVEMENT AS THE DEPENDENT VARIABLE

Perceptual Test	Second Grade R^2	R	F	Fourth Grade R^2	R	F	Sixth Grade R^2	R	F
VF/P_tRS (Speed)	.333	.57	23.99	.302	.55	23.35	.378	.62	32.79
VM/P_gAmF (Size)	.376	.61	3.25	.335	.58	2.68	.394	.63	1.43
VF/P_gAmF (Shape)	.394	.62	1.31	.383	.62	1.64	.405	.63	.98
$VP_g/RAmF$ (Position)	.399	.63	.39	.364	.60	2.30	.407	.64	.11

factors was computed for the 4th and for the 6th grades (Winer, 1962). The results of the analyses of variance are shown in Table 17.

TABLE 17

ANALYSIS OF VARIANCE FOR ACHIEVEMENT, SPEED OF PROCESSING, AND AMOUNT OF INFORMATION PROCESSED

Source	Fourth Grade df	MS	F	Sixth Grade df	MS	F
Between Ss	29			29		
A (Achievement)	1	61.25	22.11**	1	55.56	28.40**
Ss within groups	28	2.77		28	1.96	
Within Ss	150			150		
B (Speed of Processing)	1	66.01	110.02**	1	85.42	158.11**
AB	1	.05	.08	1	1.09	2.02
B x Ss within groups	28	.60		28	.54	
C (Amount of Information Processed)	2	63.78	65.08**	2	38.85	52.50**
AC	2	4.05	4.13*	2	4.31	5.84**
C x Ss within groups	56	.98		56	.74	
BC	2	1.54	8.11**	2	1.01	1.74
ABC	2	8.02	42.21**	2	2.04	3.52*
BC x Ss within groups	56	.19		56	.58	

*Significant at .05 level
**Significant at .01 level

Factor A in these analyses was composed of two levels of achievement. The two levels were formed by selecting for each grade persons whose California Achievement Test scores were in the upper or lower 27% of the distribution of achievement scores. Factor B was composed of two levels of duration of stimulus presentation. At the short duration level, words were presented at 1/24 and 2/24 of a second, and at the long duration level stimulus presentation times were 6/24 and 7/24 of a second. There were six trials for each level. Factor C was made up of three levels determined by the amount of information (one word, two words, or three words) presented. There were four trials at each level.

All three main effects at each grade level were significant. The main effects for factor A in both grades indicated that high achievers received higher scores on the speed of processing information test than low achievers. Factor B revealed significant differences between speed of processing information scores for different durations of stimulus presentation. The main effects of factor C showed significant differences in speed of processing information scores based upon amount of information to be processed.

Significant interactions are reported in Figure 10, page 65. The AC interactions in both the 4th- and 6th-grade analyses suggest that as amount of information to be processed increases, the difference in performance between high and low achievers becomes greater. The differences between high and low achievers for the 4th grade was significant at the .05 level for c_1 and at the .01 level for c_2 and c_3, while for the 6th grade the differences were significant at the .01 level for $c1$, c_2, and c_3.

The BC interaction, which was significant only in the 4th grade, suggests that the effect of duration of stimulus presentation on information processed increases as the amount of information to be processed becomes smaller. However, the differences between the two levels of Factor B were significant at the .01 level of significance for all levels of Factor C.

The ABC interactions of the 4th and 6th grades suggest that when the

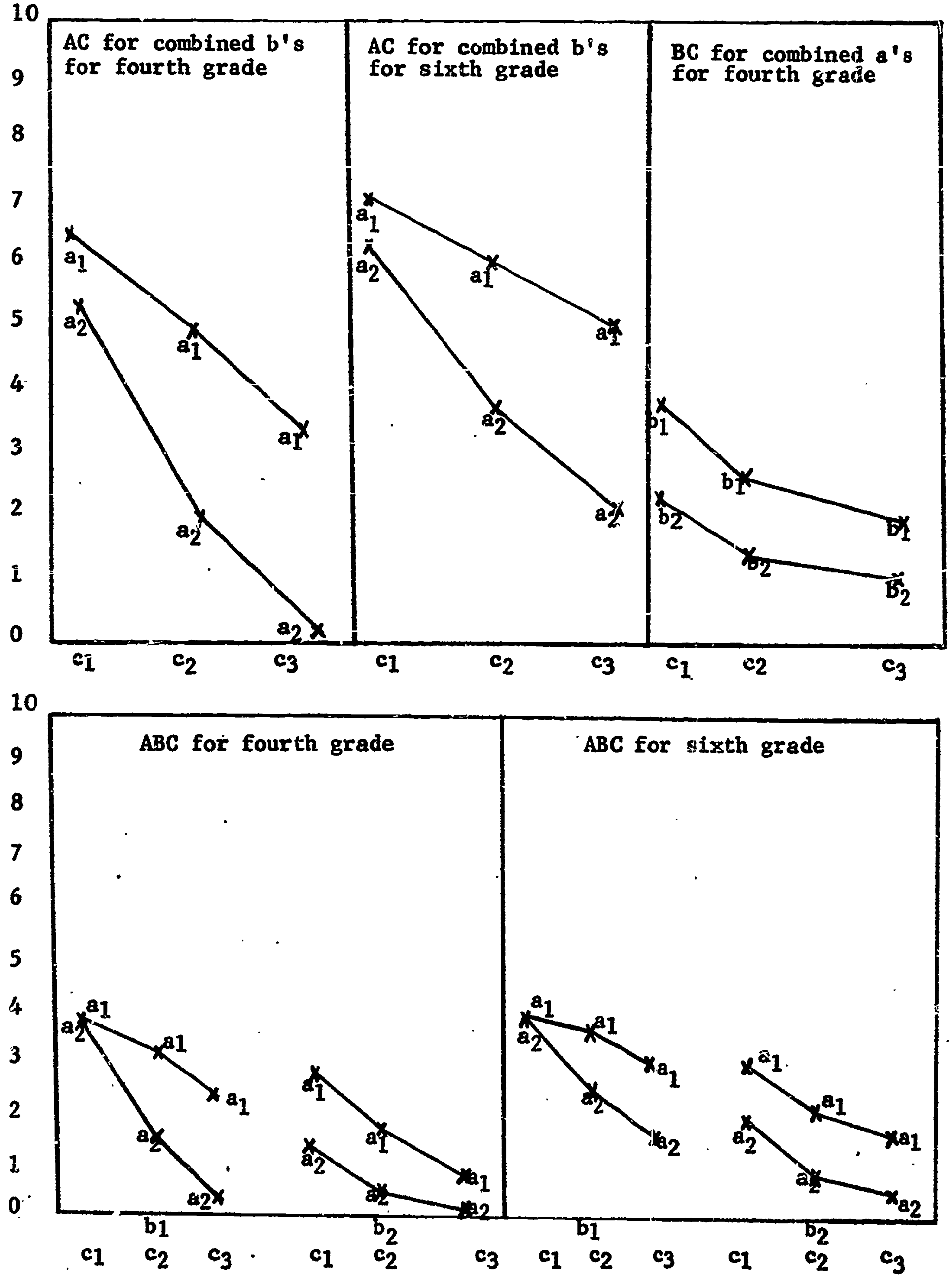

Figure 10

Interactions

duration of presentation is long and the amount of information to be processed is small, there is no significant difference between the performance of high and low achievers. However, as the amount of information to be processed increases, the difference between high and low achievers becomes significant. When the duration of presentation is short, there is a difference between the performance of high and low achievers. As the amount of information is increased, the difference in performance between high and low achievers increases. The differences between high and low achievers for the 4th and 6th grades were not significant for b_1 c_1, while there were significant differences between high and low achievers at b_1 c_3 for both grades. The results for A at b_2 c_3 for the 4th grade were not significant. For the 6th grade, however, A at b_2 c_2 and b_2 c_3 were significant at the .01 level.

To determine the effects of sex and age on perceptual abilities in the 4th- and 6th-grade groups, a three-factor analysis of variance with repeated measures on the last factor was performed. The results of this analysis did not indicate any significant age or sex differences in the 4th- and 6th-grade groups.

DISCUSSION

Speed of Processing Information

Of the perceptual variables under study, speed of processing information yielded the strongest relationship with reading achievement. This result, coupled with Gilbert's findings with college students, suggests that speed of processing information is a variable of substantial importance in the reading of children and adults.

The fact that the relationship between speed of processing information and reading occurs across a large age span is especially significant since to date such generalization has not been reported in the literature for any other perceptual measure. A number of investigators have felt that perception is important in reading only at the lower grade levels, e.g. Frostig (1964). The speed of processing information findings suggest the need for altering this notion.

The results of the analyses of variance presented in the last section of this report indicate the contributions of both duration of stimulus presentation and amount of information to be processed to speed of processing information ability. It is important to know the extent to which the main effects and interactions observed in the 4th and 6th grades would hold for other age groups. The fact that a significant BC interaction occurred only for the 4th grade indicates the possibility that developmental changes may exist with respect to the influences of amount of information processed and duration of stimulus presentation.

The specification of the defining features of speed of processing information represents a most important research task. As indicated earlier one way to determine these defining features would be to use a focusing strategy to systematically vary the defining components (contents, stimulus characteristics, tasks, and sense modalities) which describe speed of processing information.

The relationship between speed of processing information and reading achievement should be investigated using all four types of content specified in the structure of visual perception model. If it were determined

that speed of processing information ability did generalize across content categories, a welcome reduction in the complexity of the structure of visual perception with important practical consequences would be effected. For example, generalization across content categories would enhance the potential use of speed of processing information in the prediction of future reading achievement in very young children.

Not all characteristics would be relevant to the determination of knowledge about the extent to which speed of processing information generalizes across stimulus characteristics. Investigations involving form, position in space, and magnitude, for example, would be pertinent. Studies involving texture, hue, brightness, and saturation would be of less importance. A job description of the reading task could provide a basis for limiting the selection of stimulus characteristics.

Investigations of the degree to which speed of processing information generalizes across tasks and sense modalities should be undertaken. As with stimulus characteristics, not all tasks and modalities would be relevant.

Spatial Orientation

The relationship between spatial orientation and achievement at the 4th grade suggests that spatial orientation is related to reading. However, the fact that this relationship did not appear at the 2nd or 6th-grade levels suggests the need for cross-validation studies.

The observed relationship between spatial orientation and intelligence raises questions concerning findings reported by Witkin. The correlation between intelligence and spatial orientation was significant in the 4th grade and approached significance in the 2nd grade. These findings support Witkin's results. However, in the 4th grade, verbal scores correlated higher with spatial orientation than non-verbal scores, which is in disagreement with Witkin's findings. Cross-validation studies should be conducted as a first step in determining the basis for the discrepancy between Witkin's results and those of the present investigation.

Constancy

The correlations between size constancy and achievement in the 2nd and 4th grades suggest that size constancy ability may be a variable of importance to reading in the early grades. It is difficult to interpret the meaning of the relationship between size constancy and achievement at the 2nd grade level since the size constancy test for this grade could be regarded as a cognitive rather than a perceptual measure. If the child were able to reason that his responses should be consistent regardless of the distance at which the standard stimulus was presented, he should have been able to perform well.

The significant relationship between size constancy and achievement at the 4th-grade level, in contrast to that for the 2nd grade, does give supportive evidence as to the importance of size constancy in reading. It is assumed that the interchange method used to measure size constancy in the 4th and 6th grades and shape constancy in all three grades minimized cognitive cues and in this respect represented a more adequate measure of constancy ability than the approach used to measure size constancy with the 2nd-grade group.

The responses of subjects on both the size and shape constancy tests provide evidence of the validity of the interchange approach. In the absence of perfect constancy, size and shape judgments should tend toward retinal size and shape. Of the 112 4th- and 6th-grade children who took the size constancy test with the interchange method, only six obtained mean judgments which did not tend toward retinal size. Five of these were 6th graders. On the shape constancy test, only one person in all three grades judged shape in a manner which did not reflect the influence of retinal shape. In the one constancy test in which the interchange method was not used (size constancy for the 2nd grade), 22 subjects made judgments which did not reflect the influence of retinal size.

Results of judgments using the interchange method raise questions about the findings of previous studies which suggest that constancy ability is well developed in childhood. The findings of such studies

may reflect the influence of cognitive cues rather than perceptual ability. To confirm this possibility, the "interchange" method could be compared with the standard procedure used for the second grade group at different age levels, using subjects as their own controls.

Another issue related to the establishment of the validity of constancy measures involves the influence of response set on constancy. It is possible that in a constancy task the subject's judgments early in a series of trials create a response set which affects later judgments. This set would provide internal consistency in performance. However, consistency would vanish on retesting. Thus, the test-retest reliability of constancy measures should be investigated.

A final needed area of constancy research involves establishing the defining features of constancy. A procedure analagous to that described for speed of processing information could be used for this purpose.

Constant Errors

It is surprising that the constant errors associated with the shape and size constancy tasks were not related to each other. Both the shape constancy and size constancy tests involve the same perceptual task: match adjustment. Thus it might have been expected that errors in performance associated with adjustment would have been correlated for the two tasks. The fact that they were not raises the question of whether or not constant errors involving successive administrations of the same test would have been correlated. The magnitude of constant error for each subject may have been a function of response set. Test-retest reliability would provide a starting point for investigating this possibility.

Sex Differences and Developmental Changes

One of the most unexpected findings in the study was the lack of developmental changes and sex differences in performance on the perceptual measures. In the case of spatial orientation, it seems likely that the analysis of variance procedure was not sufficiently sensitive to pick

up significant sex differences. The significant correlations between sex and spatial orientation provide support for this assumption.

One reason that no developmental changes were observed is that the age ranges selected for study were too small. The fact that differences did exist between means for both the spatial orientation test and the speed of processing information test suggests the need for further developmental research using broader age ranges.

STRATEGIES FOR FUTURE RESEARCH

The structure of perception model, coupled with results of the present project, calls for a reconsideration of the aims of research and assessment in perception and reading. As reported in the related literature section, perceptual research and assessment in education have focused primarily upon the problem of establishing and measuring general perceptual ability.

The complexity of perception illustrated by the structure of perception model points out the impracticality of the search for a general perceptual ability, and the results of the present project, as well as past research, suggest that no such ability exists.

A general perceptual ability could be created by establishing a hypothetical construct combining empirically unrelated categories. This is the procedure which has dominated intelligence assessment since the beginning of this century. Results of the multiple regression analyses previously presented suggest that such an approach could be used in perceptual assessment. Even disregarding the substantial relationship between speed of processing information and achievement, the contributions of size constancy and spatial orientation to multiple correlations with achievement suggest that a test composed of a series of perceptual measures, each contributing a small amount to an overall relationship between perception and achievement, probably could be constructed. However, such a test would provide a vague definition of perception and would not lead to the specification of how perception functions in the accomplishment of academic tasks.

Goal-related selection could be used to achieve the complexity reduction which was the aim of the search for a general perceptual ability. As pointed out in the problem section a great deal of the complexity which exists in perception results from the fact that perceptual ability has been defined without reference to the situations in which it is applied. Goal-related selection implemented through system theory offers a basis for linking perceptual abilities to the situations

in which they are used.

System theory and the structure of perception model could be combined to launch a search for perceptual abilities relevant to reading and other academic skills. Job descriptions based on video recordings of reading and other academic behaviors might be used to provide the basic information for subsequent task analyses. The task analyses would eventuate in hypothesized abilities to be described in terms of the structure of perception model and investigated with respect to their relationships to school achievement.

APPENDIX A

TEST INSTRUCTIONS

Speed of Processing Information Test

Before beginning the test, each child is asked to read orally the list of words which is used on the test. This procedure insures familiarity with the words to be used, thus eliminating the possibility that the test is measuring word recognition rather than speed of processing information.

The following instructions are given to each subject: "I am going to show you a film that has on it some of the words you just read. The first thing you will see is a black dot that shows where the word will be on the screen. Look closely at the place where you saw the dot, for the first word will appear there for just a short time and then a second word will come on. After the second word has gone off the screen, circle the word on your list that is the same as the FIRST word that you saw. After you do that, a new word will come on the screen. Do the same thing as you did with the first word."

Spatial Orientation Test

The subject is asked to tilt his head to the left and the following instructions are given: "You see this pencil?" (The experimenter tilts the pencil to the left within a rectangular frame analagous to the frame used in the spatial orientation test.) "Is it straight up and down like a flagpole or like the walls of this room?" (If the subject answers correctly, the experimenter says, "You make it straight up and down." If the subject answers incorrectly, the experimenter indicates the straight up and down position by altering the position of the pencil.) Then the pencil is tilted in the direction opposite to the head tilt. The subject is asked to make the pencil straight up and down for three head positions (left tilt, straight up and down, and right tilt.)

"Now we are going into a room that is dark. You will be asked to do a task like the one that you just did. Now let's put the blindfold on." A mask is then placed over the subject's eyes. The experimenter leads the subject to the Witkin chair, seats him, and places his right

hand on the switch which controls the movement of the rod. (In the 2nd-grade group, buttons were used instead of the switch.) "Push the switch forward and the rod will move one way and now push the switch to the middle position and the rod will stop. Now pull the switch back and the rod will move the other way. Now put the switch to the middle position and the rod will stop. This is a chair that will tilt. Now I am going to tilt you this way, and now I will tilt you the other way." (Chair is tilted to the left and then to the right and the test begins). "Now remove your blindfold from your eyes, pull it up on your forehead, but don't take it off. Do you see the rod? Make the rod straight up and down like the walls of a room. Tell me when you have finished." After the subject says he is through, the experimenter says, "Pull the blindfold down over your eyes again." The instructions dealing with removal of the blindfold are repeated for each trial.

Size Constancy Test

The experimenter says, "Do you see the two circles in front of you? Are they the same size? I will change the size of this one (pointing to the variable) and when it is nearly the same size as the first one (pointing to the standard) you say, 'Stop'. Then I will ask you if you want it bigger or smaller to make it exactly the same size as the one on the table." On each trial after the initial adjustment, the experimenter says: "bigger or smaller".

Shape Constancy Test

After the subject has placed his chin on the chin rest, the experimenter points to the standard circle on the table and says, "See this shape?" (Experimenter then points to the variable ellipse.) "Now do you see this shape? Is it the same as the first one? I will change the shape of this one and when it is nearly the same shape as the first one, you say, 'Stop'. Then I will ask you if you want it bigger or smaller to make it exactly the same as the shape on the table." On each trial after the initial adjustment, the experimenter says, "bigger or smaller."

Word Reversal Test

A list of words is presented to the subject and he is told, "I want you to read all of these words. Read each word and guess if you are not sure." (The subject should attempt every word without help from the experimenter.) "Read the words out loud."

Score a minus for each reversal error, even if the error is spontaneously corrected by the subject. Some examples of errors are: dig or pig for "big"; small for "malls"; rat for "tar"; from for "form".

Reversed Words in Context Test

The list of sentences is presented to the subject and he is told, "Read the sentences and guess if you are not sure." (The subject should attempt every sentence without help from the experimenter.) "Read the sentences out loud." The scoring is the same as for the word reversal test.

APPENDIX B

RESPONSE FORMS FOR SPEED OF PROCESSING INFORMATION TESTS

Name ______________________________
last first

DRAW A CIRCLE AROUND THE CORRECT ANSWERS

SECOND GRADE

1.	the end term hard large
2.	are sat wet saw not
3.	and ask cut eat use
4.	yes hat bed try get
5.	yet who bat web was

6.	for why say red ran
7.	far put its fly tap
8.	see dog all can any
9.	bad did dip boy bib
10.	let net leg hit ten

11.	moo nap big man mat
12.	fat how top toy cat

1.	she ran big dog be here did eat his car
2.	here now say this good boy saw them new toys
3.	our work call her over there one boat his name
4.	far away this cow two cats it comes pull him
5.	old book go there get spot grow big so small

6.	last one blue toy kick it back here ten bats
7.	she sat soft snow come home that pen help me
8.	even line who eats what chick was over last shoe
9.	did turn desk top dry dish deep hole any bend
10.	four eyes rich man nice pig your pen pick that

1.	my new hat time for play boy and girl on the field we can guess
2.	his dad's shoe we came back he ran away your left hand they all went
3.	in the rain on his arm tall red pole find a barn to my room
4.	they came in look for him it is white into that cave hot tea cup
5.	father buys cake drop back here send four cards five baby ducks paper tears easy

6.	cars go fast can he walk who is here cats are nice see the wall
7.	time is long away all boats what a train better be good with a bike
8.	tell us why see the doll pool of water sea gulls fly down it goes
9.	flat tiny dish pigs are fat part of feet sky is blue across the road
10.	many of them play a drum jump a stick draw the peg plant a seed

Name ______________________________
last first

DRAW A CIRCLE AROUND THE CORRECT ANSWERS

FOURTH AND SIXTH GRADES

1.	the end term hard large
2.	are sat wet saw nod
3.	and ask cut eat use
4.	yes hat bed try get
5.	yet who bat web was

6.	for why say red ran
7.	far put its fly tap
8.	see dog all can any
9.	bad did dip boy bib
10.	let net leg hit ten

	moo
	nap
11.	big
	man
	mat
	fat
	how
12.	top
	toy
	cat

1.	big	ran
	did	here
	she	car
	be	eat
	his	dog
2.	say	boy
	new	them
	saw	this
	here	toys
	good	now
3.	over	there
	call	name
	his	boat
	our	work
	one	her
4.	it	cow
	far	cats
	pull	comes
	this	away
	two	him
5.	grow	spot
	old	there
	so	big
	get	small
	go	book

6.	last ten back blue kick	bats here it one toy
7.	soft she help that come	me sat home snow pen
8.	who even last what was	line eats over shoe chick
9.	desk dry did any deep	hole top turn dish bend
10.	nice four pick your rich	eyes man pig that pen

	my	and	play
	boy	for	hat
1.	we	the	girl
	on	new	guess
	time	can	field
	he	left	back
	we	ran	hand
2.	they	dad's	went
	your	came	away
	his	all	shoe
	on	the	pole
	in	his	rain
3.	to	a	barn
	find	red	arm
	tall	my	room
	it	for	in
	hot	is	cave
4.	into	tea	him
	look	that	white
	they	came	cup
	drop	four	easy
	father	baby	cake
5.	paper	back	cards
	five	buys	ducks
	send	tears	her

	cars	is	walk
	see	go	here
6.	cats	he	fast
	who	the	nice
	can	are	wall
	away	is	train
	time	all	good
7.	with	be	bike
	what	a	long
	better	a	boats
	see	it	why
	sea	the	fly
8.	tell	gulls	doll
	pool	us	goes
	down	of	water
	across	of	blue
	sky	are	feet
9.	part	the	fat
	pigs	is	dish
	flat	tiny	road
	plant	the	stick
	jump	a	seed
10.	play	of	peg
	draw	a	them
	many	a	drum

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